



Our experience thus far confirms that of others that the maintenance of an aciduric flora reduces putrefactive bacteria in the feces and thus decreases their theoretically harmful products. We concur with Kulp that the chief criterion is whether or not the subject shows clinical improvement and that this should go hand in hand with the appearance of large numbers of *Lactobacillus acidophilus* in the stools. Our experience confirms the reports of other workers that such does occur, and that the clinical benefit obtained will, in many cases, persist after the therapy is discontinued.

Through the kindness of Dr. Samuel Hoffman, resident physician of the Children's Ward of the Cook County Hospital, we now have the privilege of studying infants with chronic eczema, but, as yet, we have insufficient data upon which to base conclusions. Arrangements have been made at this and other hospitals to study the value of *Lactobacillus acidophilus* in the treatment of summer diarrhea in infants.

#### CONCLUSIONS

1. *Lactobacillus acidophilus* can be

implanted in the human intestinal tract and become the predominating flora.

2. Viable cultures of *Lactobacillus acidophilus*, when administered in sufficient quantity and with regularity, are of benefit in the treatment of ailments directly or indirectly referable to disturbed function of the digestive tract.

3. *Lactobacillus acidophilus* is antagonistic to a putrefactive type of flora and thus reduces their toxicogenic substances.

4. *Lactobacillus acidophilus* was found of benefit in most of our cases of chronic constipation and in some cases of mucous colitis and diarrhea.

5. In a single case of a persistent typhoid carrier, disappearance of the typhoid organisms from the stool was coincident with the appearance of a predominantly aciduric type of fecal flora.

#### DISCUSSION

DR. ALBUS: In reply to the question as to implantation, it might be defined as that which is accomplished by the ingestion of the material to be implanted; the method was the ingestion of the milk, orally, and the implantation, subsequently, of these organisms.

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# The American Journal of Surgery

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NEW SERIES, VOLUME XII

APRIL TO JUNE

1931

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## The Noble Nature

It is not growing like a tree  
 In bulk doth make man better be;  
 Or standing long an oak, three hundred year,  
 To fall a log at last, dry, bald, and sere:  
 A lily of a day  
 Is fairer far in May,  
 Although it fall and die that night;  
 It was the plant and flower of light;  
 In small proportions we just beauties see;  
 And in short measures life may perfect be.

After poetry, probably the kinds of literature least read in this country, except by scholars, are letters and memoirs. They are most admirably suited to leisurely reading, whether they be the worldly reminiscences of a St. Simon or the naively beautiful missives of an Emily Dickinson. It is generally the recollections and correspondence of political figures which attain to wide circulation, and these take their interest chiefly from the background of events. The revelation of striking personalities, however, comes more often in the informal writing of literary men; and many who would be interested never find it. Few who read Whitman or Byron, for example, know the reminiscences of the one or the letters of the other.

An interest in letters and memoirs will supply a good foil to those whose chief reading must be novels and stories; for the tendency of most readers will probably be to go in too strongly for fiction. Yet even here they may indulge themselves greatly if they can be interested in the great novels of which Europe has produced so many. The curse of present-day fiction reading is the magazine. It has resulted from a demand for a kind of writing which is suited to overtired bodies and minds. The worker, with a half an hour to spare at the end of his day, may derive a certain contentment from a story which carries him as far as the toothpaste advertising and makes no demand on anything but his eyes while so doing. But the sick-bed reader will find that this kind of writing, trite, mechanical, and circumscribed, becomes downright dull in a very short time.

And oftentimes he will remain bored simply through lack of knowledge of the succor which lies at hand.

Well do I remember the remark of an old man whom I used to visit, who during the last years of a long life was confined to his chair. "I am never lonely," he said. "I have never been lonely, for I have lived countless lives. I have always had Dickens." And indeed the world which Dickens peopled with such living characters had long ago assumed for this man reality equal to the one which lay around him. It is because writers like Dickens, Thackeray, Trollope, Stevenson and Hawthorne have created such worlds that it is better to recommend them rather than "one book men" like Norman Douglas, Somerset Maugham, and the ill-fated George Douglas (Brown). For while "South Wind," "Of Human Bondage," and "The House with the Green Shutters" are great novels, the reader may be disappointed in others by the same authors; whereas the opulent writers we first mentioned can be read for weeks on end without exhausting them.

Many patients may enjoy short stories, and here one may find excellent examples not only among the classic short story writers like Poe, Chekov, de Maupassant, Hoffman, and Bierce, but among contemporary masters as well. The short story has assumed great importance in our own day, and writers like Irvin Cobb, Don Marquis, Ring Lardner, and Kathleen Norris are adepts in the art.\* Where the patient is limited to brief periods of reading, this may be the best form of fiction to prescribe. Yet one must beware of overworking the short story. It is a limited form, perhaps the most limited form, and one may tire quickly of short stories if one reads them too often without relief.

Perhaps throughout this paper we have seemed too insistent upon books which have stood the test of time, preferring the classic to the contemporary, the lasting to

\* Vid., Cobb, "Old Judge Priest"; Marquis, "When Turtles Sing"; Lardner, "Roundup"; Norris, "The O'Callaghans," and "The Murphies."



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**D. INTRAVENOUS INFUSION:** The method of intravenous infusion consists of the introduction of fluid directly into the blood stream by means of a needle or cannula inserted into a

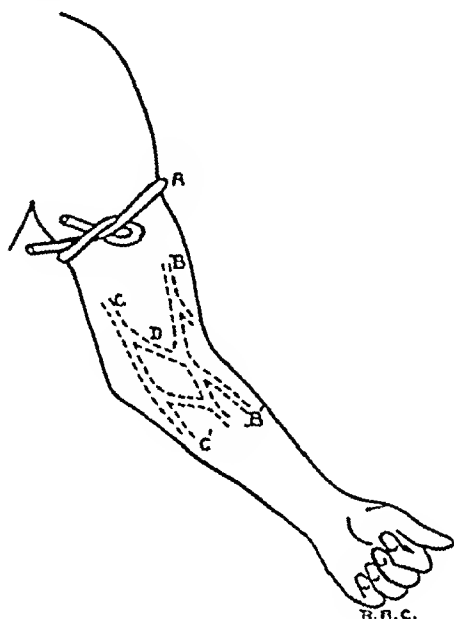


FIG. 31.

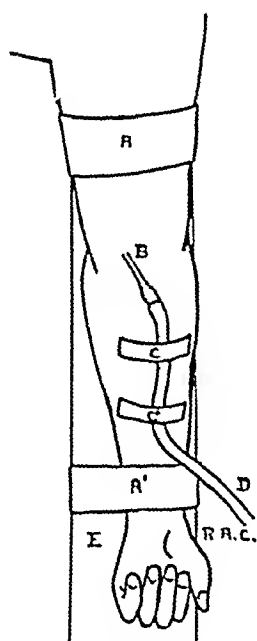


FIG. 32.

FIG. 31. Proper method of applying piece of rubber tubing as tourniquet to arm for purposes of distending veins at bend of elbow and usual distribution of superficial veins in antecubital fossa. Rubber tubing A is tied only sufficiently tightly about arm to occlude venous return and not so tightly as to embarrass arterial blood supply. Note that the knot made by rubber tubing is in the nature of a slip-knot which can be released by simply pulling proper end of tubing; advantage of this is that release of tourniquet requires use of only one hand. Arm band of blood pressure apparatus makes an admirable tourniquet and presents especial advantage that pressure exerted by it can be controlled manometrically; accordingly, this device is offered merely as a substitute in case no blood pressure apparatus is readily available. Veins illustrated are B-n' cephalic vein, C-C' basilic vein, and D median cubital vein.

FIG. 32. Drawing illustrating technique of intravenous infusion. E is wooden board of suitable dimensions; it passes under back and shoulders of patient. A and A' are strips of adhesive plaster or layers of bandage which fasten arm and forearm to board. B is infusion needle which has been inserted into one of the antecubital veins. C and C' are strips of adhesive plaster which hold needle B and rubber tubing D in permanent position.

vein. The procedure is a relatively heroic one, but for efficiency supersedes all other methods. It is not without danger, partly

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curvature. The man was losing rapidly in weight and his color was bad. At an exploratory operation, the walls of the whole antrum and

just had a voluminous gastric hemorrhage. X-ray studies in the man failed to disclose a definite lesion. At operation on both patients

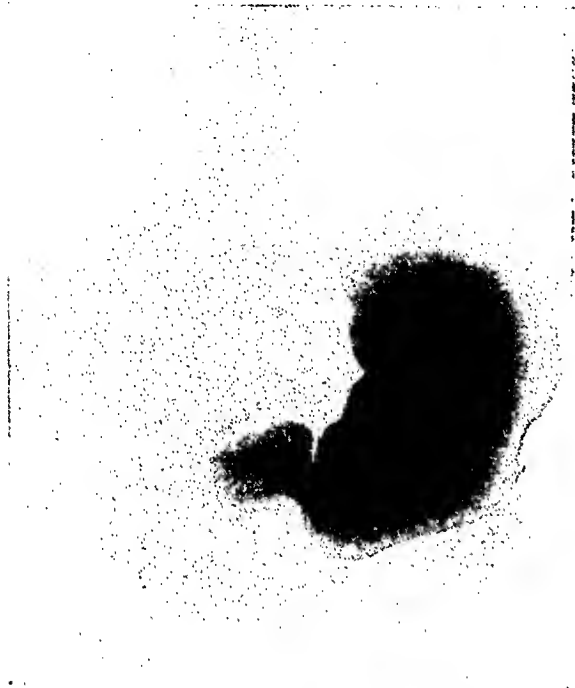


FIG. 3. Duodenum and antrum after excision of duodenal ulcer and Finney's pyloroplasty. Case symptom-free but nothing to be gained from study of contours.

corpus were thickened and hard, the picture of the so-called leather bottle stomach. There were no glands. After the exploratory operation he was seen in consultation with Drs. Kelly and Burnam who advised radium and x-ray and Dr. Finney who suggested the possibility of a total or subtotal gastrectomy. The patient chose the easier and useless route of treatment with x-ray and radium. He rapidly reached the point where he could not be fed by mouth on account of extreme gastric distress and aversion to food. For the purpose of feeding a duodenostomy was done and in this way he was fed until he died. Conditions of living could not have been worse for him if a gastrectomy had succeeded and if he had died, he would have been relieved of months of suffering and a useless life.

CASES V and VI. Two cases, one of a man sixty-four years old, Jan. 8, 1921, the other a woman sixty-nine years old Jan. 30, 1924. Both complained of gastric distress, both had lost weight, the man, 42 lb.; the woman had



FIG. 4. CASE III. Collar button crater from posterior surface of stomach in upper part of corpus, near lesser curvature. Shown only in oblique position. This crater was fixed to pancreas, did not shift with movements of stomach and caused unbearable pain.

there was found an indurated area the size of a dollar in the anterior wall of the antrum, with a large shallow crater. In the woman the induration extended up to and embraced the lesser curvature; in the man, neither curvature was involved, the lesion was nearer the greater curvature. In both cases there were a few glands along the lesser curvature near the pyloric canal. A gastrectomy with resection of the whole antrum, about half the stomach, was done in both patients. Pathological section in the one case, the man with the ulcer frankly and freely on anterior surface of the antrum showed malignancy; in the other case, the woman with the ulcer nearer and embracing the lesser curvature showed no malignancy. Both patients are living and well, the woman after six years, the man after nine years. Since two months following their operations both have eaten practically a full diet, have regained weight and color and have no gastric distress. X-ray studies following gastrectomy show the stomachs while somewhat reduced

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# The American Journal of Surgery

NEW SERIES, VOL. XII

APRIL, 1931

No. 1

## THE STATUS OF SURGERY FOR PEPTIC ULCER:

SOME REFLECTIONS INDUCED BY THE 1930 SYMPOSIUM OF THE AMERICAN SURGICAL ASSOCIATION\*

URBAN MAES, M.D.

NEW ORLEANS, LA.

I AM not the only surgeon, I am sure, who looked forward eagerly to the 1930 symposium of the American Surgical Association, which was planned to include both collective and individual reports from some of the foremost surgeons of America on "the ultimate results of operations for gastric and duodenal ulcers." I am not the only surgeon, I am sure, who mentally prepared a paper to be based on the summing up of those reports. I am not the only surgeon, I am sure, who was bitterly disappointed to find that the more than 4000 cases reported in those brilliant and helpful and provocative communications are useless for the purposes of collective study, for the reason that practically every series is based upon a separate premise. Never has the personal equation wrought more statistical disaster, and the fact that my processes at no time passed beyond the mental stage leaves me no whit less grieved for the unsurpassed collective study that might have been and now can never be.

I comfort myself, however, with the thought that the "long view," so essential in every branch of medicine, can perhaps be achieved as well by general considerations as by cold figures, especially when those considerations represent the aggregate opinion of men whose eminence in their chosen field is beyond question or cavil. My remarks are naturally colored by my own ideas, but in the main they are

composite and not personal, collective and not individual.

The medical treatment of peptic ulcers cannot be altogether ignored even in a strictly surgical symposium. Moynihan, the philosopher, whose unparalleled surgical results entitle him to his point of view, confesses that he takes "only a languid interest" in this perennial problem, but most of us are less fortunate in our endeavors, and for us it has a disconcerting way of crossing our field of consciousness. Medical treatment unquestionably has its merits. It is not only better than poor surgery, it does not introduce the active element of risk which is inherent even in the best surgery. The patient in the intensity of his misery may sometimes wish that he were dead, but at least his end is not precipitated by the remedies being employed to relieve him, though it must likewise not be forgotten that death may occur in spite of and in the course of medical treatment, from hemorrhage, perforation, or complications such as the toxemia described by Balfour and others. Moynihan, for instance, cites 3 cases in his own practice in which, within a year, death occurred from hemorrhage, and in all of which surgical intervention had been postponed in favor of medical measures. Such dramatic coincidences are fortunately rare, but when they do occur, the patient is just as dead as if he had died after surgery.

Medical treatment has certain specific

\* Read before the Southern Surgical Association at Lexington, Kentucky, December 9-11, 1930.



indications: poor surgical risks, at least until they can be rehabilitated; the so-called "fresh" or "recent" ulcers; ulcers with slight symptoms; ulcers without cicatrization and obstruction; and, most particularly, ulcers in young people. Indeed, in no case is there any excuse for a resort to surgery until medical methods have been given a fair trial, though I question whether this will reduce the incidence of operative intervention to the 10 or even the 20 per cent suggested as proper by so eminent an authority as Dr. Bevan. Practically every ulcer I have ever operated on—and I feel sure that this is the experience of most surgeons—has been cured more than once, sometimes more than the nine times suggested as fair by W. J. Mayo, on the analogy of the cat's chances of life. For that reason I am rather skeptical as to the permanence of the medical cures I see reported in such numbers in the literature. I freely grant the quiescence of symptoms under medical treatment, and it would be unkind to add that remissions are characteristic of this special disease, with or without therapy of any kind.

A decision to operate based on economic considerations unquestionably has an unscientific aspect, but it would be futile to ignore such considerations entirely. Few wage-earning men and women can afford, as W. J. Mayo characteristically observes, "to make a pet of an ulcer," and to undergo the long period of rest and treatment necessary for a medical cure, not to mention the later difficulties of observing a specified and restricted and specially prepared diet in these days of boarding-house existences and tabloid housekeeping. And the restrictions frequently go beyond dietary ones. I am constantly appalled to read that in obstructive lesions a part of the cure depends upon the nocturnal emptying of the stomach by a stomach tube, the writers naively implying that certainly results cannot be expected if directions are not followed, from which I infer that patients have a tendency to ignore this special regulation.

They have my sympathy: I may be captious, but if I had to live on a special diet and to empty my stomach nightly with a tube, I question very much whether I should consider myself even improved, let alone cured.

There are two final arguments against medical treatment. In the first place, it is impossible to determine absolutely by any means other than surgery that one is really dealing with an ulcer, and that continued symptoms are not due to lesions elsewhere in the intestinal tract or in the gall bladder or appendix. I have operated with the strongest conviction that an ulcer existed, backed by apparently irrefutable clinical and radiologic evidence, and have found no trace of it, the symptoms being mimicked by other intra-abdominal pathology. In the second place, it is impossible to cure by medical treatment other coexisting or, if you choose, causative intra-abdominal lesions, without the correction of which even the most ideal healing of an ulcer will not give relief.

I have dealt at perhaps unjustifiable length with the question of medical treatment, for the reason that one gathers from the papers presented before the American Surgical Association that the surgery of peptic ulcer is, to a certain extent, on the defensive. Well, surgery is frankly an evil, though it is clearly the lesser of two. It should certainly be resorted to only when an absolute indication for it exists, if for no other reason than that it carries an inevitable risk. The question is simply whether that risk is small enough to be outweighed by the benefits to accrue from surgery, and whether those benefits, again taking the "long view," are sufficiently great to outweigh and surpass the benefits of medical treatment, with its minimal and accidental risk to life.

Mere surgical recovery is obviously not enough. The patient must not only escape death and be relieved of his immediate symptoms; he must remain well. He must be observed for months and years, if not, as some authorities demand, for the re-

mainder of his life. For my own part, my test of end-results is the patient's opinion of his own state. I have a liking, which I admit is old-fashioned, for clinical improvement, and the patient, so far as I am concerned, says the last word on the subject. If he tells me he is well, I see no reason why I should plague him with repeated radiographic and chemical studies, I see no reason why I should continue to treat him or refer him to others for treatment because the radiographic or chemical results of my operative performance are not quite according to some medical Hoyle.

The results reported to the American Surgical Association, which I judge were calculated very strictly indeed, are practically all based on the premise that the surgery of peptic ulcers has a dual aspect. I emphasize this point, for there has recently appeared a very brilliant paper on this subject, which opens with the statement that gastric and duodenal ulcers are in all respects of the same genus. Even if the etiology—about which, as yet, we know very little—should prove to be the same, the resemblance stops there. In location, in pathology, in their life history, and especially in their tendency to malignant change, gastric and duodenal ulcers are radically different. Certainly the consensus of opinion in the American Surgical Society is that they should be so regarded.

Gastroenterostomy was done in by far the largest number of cases reported, which is another very important fact. We have recently witnessed the spectacle of a considerable number of Continental surgeons, and a smaller group of American surgeons, for whose brilliant performance I have a most proper respect, advocating the routine treatment of all peptic ulcers not by the conservative and relatively safe procedure of gastroenterostomy but by the radical and absolutely dangerous operation of gastrectomy. I admit that gastroenterostomy is an indirect approach to a cure, that it does not eliminate the offending lesion, and that it is applicable chiefly to the duodenal variety of ulcer, which

happens to be the commoner variety, though the impression that it gives uniformly poor results in gastric ulcers cannot, as I shall show you shortly, be substantiated by facts. I admit that gastrectomy has a wide field in the treatment of gastric ulcers. I am even willing to admit that it has a limited field in the treatment of duodenal ulcers. But I join with the participants in this symposium in asking what possible logic there can be in the performance of an operation which involves the removal of a large area of normal gastric tissue for the cure of an ulcer which is extragastric and which can be successfully handled by other and less radical methods. Is it not specious reasoning to advise the average surgeon, who does the bulk of all surgery and whose judgment and skill both tend to be rather limited, to perform routinely an operation which demands all the resources of a highly trained and experienced surgeon? I agree with Seward Erdman: Dr. Berg and his confrères have shown us how to do gastrectomy for all peptic ulcers, but they have not yet shown us why.

Any operation whose technique has been standardized but whose indications have not been is likely to be abused, and gastroenterostomy owes a fair share of its failures to that combination of facts. It fails because it is performed when it should not be, in cases eminently fitted for other measures and totally unfitted for it. It fails because it is done on the suspicion instead of the demonstration of an ulcer. Moynihan has repeatedly emphasized that an ulcer which cannot be demonstrated does not exist, that if it is there at all, it is there for all to see, since no gifts of vision are conferred upon the surgeon that are denied to his audience. Gastroenterostomy fails because of technical errors. It fails because the preoperative preparation has been inadequate, because foci of infection, the causative foci, if you will, have not been eliminated. It fails because of inadequate postoperative care and because of postoperative indiscretions, of which the con-

tinued use of tobacco is not the least. It fails because of extraneous factors, such as individual ulcer susceptibility and constitutional inferiority. It fails because other concurrent lesions have not been corrected. But even with all of these causes, surely such an unfortunate group of statistics has rarely been reported as that emanating some years ago from Mount Sinai Hospital in New York, a total failure of more than 50 per cent and a 30 per cent subsequent incidence of marginal ulcer.

Berg and his associates take these figures as a sufficient warrant for the routine performance of gastrectomy for all peptic ulcers, whether gastric or duodenal. But the reports of the American Surgical Association show no such results, and it is comforting to those of us who view the proposals of the New York group with something akin to dread to note that in the papers read in Philadelphia last May, the percentage of cures after gastroenterostomy for duodenal ulcer is in the neighborhood of 88 per cent. It is equally comforting, if rather more unexpected, to note that the percentage of cures after gastroenterostomy for gastric ulcer, in which the field of operation is admittedly limited, is in the neighborhood of 78 per cent.

To take a single illustration, Balfour reports a series of 500 cases of gastroenterostomy for duodenal ulcer, supplementing a series of 1000 cases previously reported, with 100 per cent protection against perforation; 91 per cent protection against hemorrhage; 96 per cent protection against recurrent ulceration; 100 per cent protection against malignancy; 87 per cent of cures; and this with a surgical mortality of 1.8 per cent. He likewise reports a series of 100 cases in which, as a procedure of necessity, not of election, gastroenterostomy was done for gastric ulcer, with 99 per cent protection against perforation; 91 per cent protection against hemorrhage; 97 per cent protection against recurrent ulceration; 94 per cent protection against malignancy; 79 per cent of cures; and a

surgical mortality of 3 per cent. It is true that the life expectancy of this group is nearly three times less than normal, whereas in the duodenal group it is well above normal, but at that, the showing is rather good for an operation frankly not adapted to this special lesion.

Balfour is a master in his field. Lord Moynihan's astonishing record of 500 gastroenterostomies without a fatality and his total mortality of less than 2 per cent is an ideal to be emulated, but not, I fear, to be generally achieved. We gain nothing by not facing the fact that such brilliant results are beyond the reach of the rank and file of us. Both of these master surgeons, however, report a mortality for gastrectomy four to six times as high as the mortalities just quoted for gastroenterostomy, and we also gain nothing by not facing the fact that the death rate of the average surgeon will be far beyond theirs. For every operation within the abdomen, particularly every operation on the intestinal tract, carries with it an inevitable mortality which increases in inverse ratio to the gravity of the procedure and the skill of the surgeon who performs it.

It is true that the relief of pain is sometimes no less urgent than rescue from impending death—I quote Lord Moynihan again—but it is likewise true that we have not the moral right to risk the lives of patients, even with the laudable aim of relieving their suffering, if that relief can be secured by equally certain and less dangerous methods. For my own part, I have not the smallest desire to run a risk of 10 per cent or more for the relief of a disease in which I can confidently expect a cure with a risk of 2 per cent or less.

For the Finsterers and the Von Haberers and the Bergs, in spite of their exquisite surgery, do have their losses. Also, a fact which is frequently overlooked, they have their recurrences. They report their failures, as honest men should, and in less skilful hands those failures will be multiplied. At the Mayo Clinic, that clearing

house for the surgical problems of the country, the percentage of recurrence after the radical operation is at least as high as after the conservative operation, and I need scarcely point out that secondary surgery, when it is necessary, is infinitely more difficult.

I commend to your careful consideration this whole group of reports, if you have not already read them. I have merely skimmed their surface in this paper, but even had I plumbed the depths, I doubt if I could have given you definite conclusions. W. J. Mayo speaks somewhere of the surgery that is done in good faith and bad judgment. Kipling, in another connection, says: "Any man who knows what he is doing, remembers what he has done, and can estimate the probable consequences of what he is going to do, knows also what he ought to do. That is the beginning of conscience, and I grant you it is an infernal nuisance." Perhaps it is, but only a combination of good faith and good judgment, with a liberal admixture of conscience and a literal application of the Golden Rule, can solve the problem of the right method of treatment for peptic ulcer.

#### SUMMARY

1. The symposium conducted at the 1930 meeting of the American Surgical Association on the ultimate results of surgery for peptic ulcers was a valuable piece of work, but does not permit the compilation of the various reports because of the different premises on which they are based.

2. The medical treatment of peptic ulcers has a definite field, but the results

are not permanent in the majority of cases; dietary and other restrictions must be rigorously observed; there is an inescapable element of risk; and the correction of coincident intra-abdominal lesions is not possible by it.

3. Surgical treatment must show, to justify its added risk, end-results at least as good as those of medicine, if not better ones.

4. It is illogical to group gastric and duodenal ulcers into one surgical classification, for their pathology and life history demand their individual consideration.

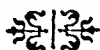
5. Gastroenterostomy gives excellent results for duodenal ulcer and only slightly less good results for gastric ulcer. It is abused and it has its percentage of failures, but these facts are no warrant for the routine performance of the difficult and dangerous operation of gastrectomy for all peptic ulcers.

6. Gastrectomy, even in the most skilful hands, has a higher mortality than gastroenterostomy, and an equal percentage of subsequent marginal ulcers.

7. The solution of the problem lies in the application to every case of good faith, good judgment, conscientiousness and the Golden Rule. We have no moral right to submit our patients to risks we would not choose to incur for ourselves.

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# FRACTIONAL GASTRIC ANALYSIS

## IN 200 CASES OF DUODENAL ULCER\*

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THE fractional gastric analysis as introduced by Rehfuß has not been given the importance it deserves in the routine study of the patient suspected of having duodenal ulcer. An extensive experience with the test carried out in the same way over a period of years has convinced us of its diagnostic value. All of the cases accepted for the review gave a characteristic history of duodenal ulcer. No previous operation had been performed for upper abdominal pathology. A complete diagnostic survey was made in each case. No other cause for the duodenal syndrome was found. A positive roentgenologic diagnosis of duodenal ulcer was made in each instance. Operation was later performed in some cases, confirming the diagnosis.

### TECHNIQUE

The method of performing the fractional gastric analysis which is described has been the same in our clinic for years. Experienced physicians supervised the work. A gastroduodenal tube of ordinary size with a metal tip is passed into the most dependent portion of the stomach. The tube is maintained in the same position throughout the examination. After aspirating the twelve-hour morning fasting stomach contents, the patient is given the meal with the tube in situ. The meal consists of approximately 35 gm. of bread and 350 c.c. of water. The usual precautions for preventing the swallowing of mouth secretions are taken. Ten c.c. of stomach contents are removed every fifteen minutes. At the end of two hours the test is terminated by completely emptying the stomach. To be certain that the stomach is empty, a lavage of 250 c.c. of water is given. The following data are recorded

on each extraction including the fasting and two-hour extractions: color, presence and quantity of juice, food, mucus and gross blood. A microscopy is carried out on the fasting residuum. Particular attention is given to food rests and pathologic products. Each fifteen-minute fraction is filtered through gauze and a titration is performed in the usual manner immediately after its withdrawal. Each filtrate is tested for occult blood by benzidine. An accurate notation is made of the amount of fluid and food in the two-hour extraction. The quantity of food sediment in the return from the lavage is also recorded.

### FASTING ACIDITY

Ryle<sup>1</sup> drew attention to the character of the fasting residuum in duodenal ulcer. He pointed out the tendency toward increase in the acidity of the fasting juice as well as in the digestive acid. The fasting residuum was described as being clear and limpid and free from mucus. A quite characteristic residuum was noted in a majority of our cases. It was thin and watery, free from gross viscid mucus and having a slightly opalescent, very pale greenish or bluish tint. Rehfuß<sup>2</sup> states that when the acidity of the fasting juice approaches the height of the digestive acidity, hyperacidity is present. For the titration we used Topfer's reagent for the free and phenolphthalein for the total acidity. A fasting residuum was not obtained in 6 cases. A classification of the level of acidity in the remaining 194 cases is shown in Table 1. A subnormal acidity was found in only 19.5 per cent of cases. The inability to prevent admixture of the gastric contents with excessive amounts of saliva, particularly in patients with hypersalivation, probably accounts for

\* From the Gastro-intestinal Clinic Graduate Hospital, University of Pennsylvania. Read at the Thirty-Third Annual Meeting of the American Gastro-Enterological Association, Atlantic City, May 5 and 6, 1930.

TABLE I  
FASTING ACIDITY

Classification of Acidity	Range of HCL.	Range of Total Acidity	No. of Cases	Percentage of Cases
Subnormal.....	Under 10	Under 20	39	19.5
Normal.....	10-19	20-34	40	20.0
Hyperacidity I....	20-34	35-49	40	20.0
Hyperacidity II....	35-44	50-59	28	14.0
Hyperacidity III...	45-59	60-69	21	10.5
Hyperacidity IV...	Above 60	Above 70	26	13.0

Average: HCL. 28; acidity 42.4, 57.5 per cent hyperacidity.

the relative number of subnormal acid cases. Fasting hyperacidity was present in 57.5 per cent of the entire series. The average free acidity for the group was 28; the average total acidity 42.4. This average is higher than we have observed in any other chronic gastrointestinal disorder.

#### POSTPRANDIAL ACIDITY

The theories concerning the mechanism of the production of so-called hyperacidity do not come within the scope of this paper. Regardless of the contention of some physiologists that true hyperacidity does not exist, one encounters in certain states of disturbed gastric function many cases showing higher levels of acidity than are found in a series of normal individuals. The existence of hyperacidity in patients with duodenal ulcer has been noted by many authors. Rehfuß found hyperacidity in 78 of 100 cases of duodenal ulcer. The percentage of cases having hyperacidity varies only slightly with various writers. Moynihan's<sup>3</sup> percentage was 78; both Bell<sup>4</sup> and Hunter<sup>5</sup> report 70 per cent of cases with hyperacidity. Others including Rosenthal<sup>6</sup> and Crohn<sup>7</sup> give figures ranging from 60 to 70 per cent.

The postprandial acidity in our cases was classified into 6 groups (Table II). Subnormal digestive acidity was encountered in only 16 cases or 8 per cent. One hundred sixty-four cases (84 per cent), show a definite hyperacidity. The latter series of cases were divided into 4 groups depending upon the height of acidity. A

TABLE II  
POST-MEAL ACIDITY

Grade	HCL.	Total	Cases
Subnormal.....	Below 35	Below 45	16
Normal.....	36-49	45-59	16
Hyperacidity I.....	50-69	60-79	62
Hyperacidity II.....	70-79	80-89	39
Hyperacidity III.....	80-99	90-109	43
Hyperacidity IV.....	Over 100	Over 110	24

Post-meal hyperacidity 84 per cent.

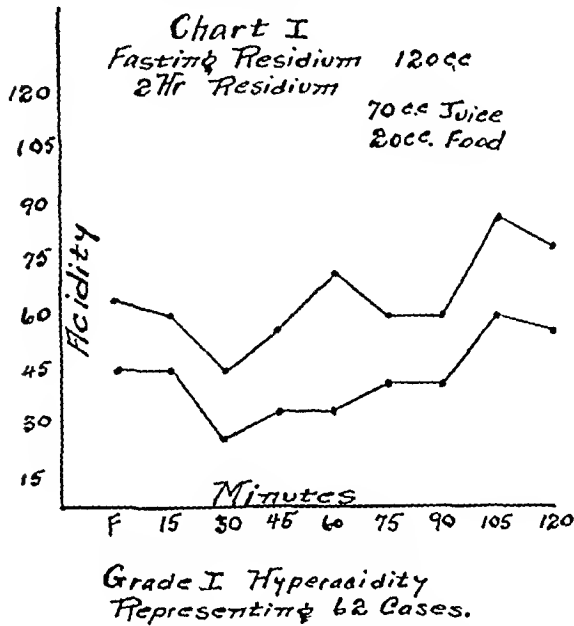
graph of the digestive acidity curve has been drawn exemplifying each group of cases (Charts I, II, III and IV). The terminal ascent of acidity described by Rehfuß in many cases of duodenal ulcer is well illustrated by these charts. The last extraction shows the highest acid level in Charts II and III. The high peak of the curve is reached in the one hundred five-minute extraction in Charts I and IV. The trend in the great majority of cases of duodenal ulcer is certainly toward a postprandial hyperacidity with a terminal-ascending type of curve which has been called an extragastric curve. Turner and Briggs found that lesions below the pylorus were more frequently associated with hyperacidity than lesions above the pylorus. Moynihan reported hyperacidity in only 20 per cent of cases of gastric ulcer. Rehfuß pointed out that the curve with a terminal rise does not occur in gastric ulcer. Our experience with gastric ulcer has been the same. Hyperacidity and the so-called extragastric curve are infrequent in ulcer above the incisura angularis.

#### EFFECT OF MEDICAL TREATMENT ON THE GASTRIC ACIDITY

Much has been written on the effect of gastric surgery on the acidity. It is a recognized clinical fact that the recurrence of ulcer is more frequent in cases in which the hyperacidity has not been overcome and an achlorhydria induced by the operation. The literature is very meager regarding the effect of medical treatment for duodenal ulcer on gastric acidity.

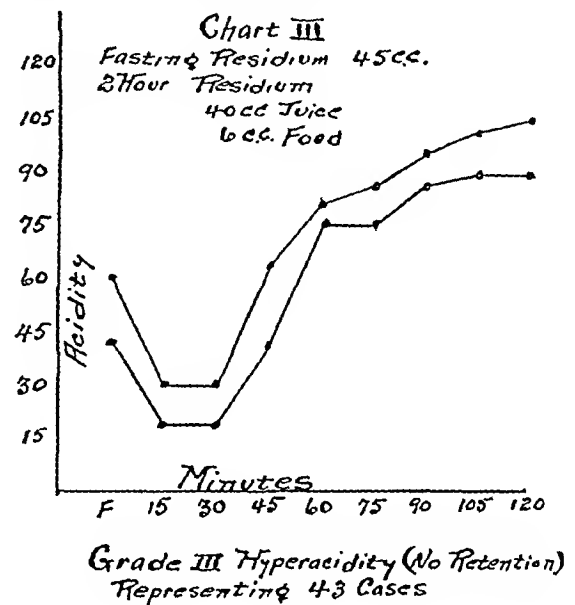
The opinion of Hurst<sup>8</sup> is undoubtedly shared by many. He found the acidity after medical treatment higher than before

71 cases chosen regardless of the original acidity. Most cases had 3 or more tests performed. Only the first and last analysis

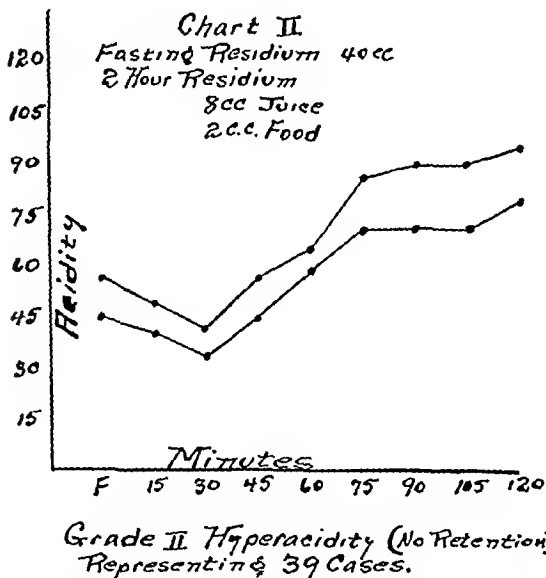


therapy and believes that the hyperacidity is more characteristic of the patient with ulcer than it is of the ulcer itself.

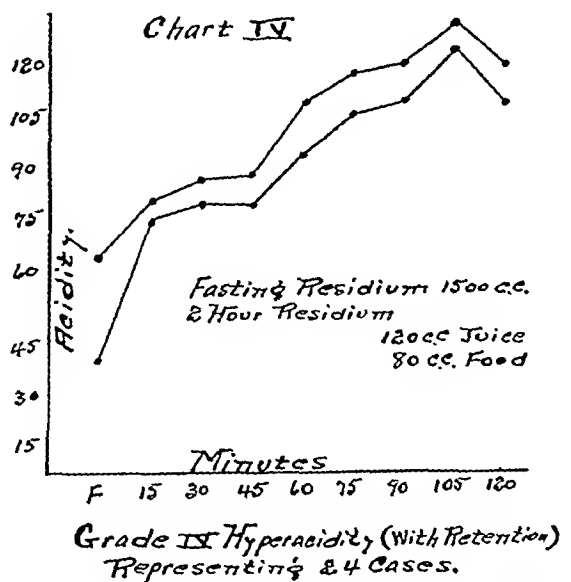
It has been our practice to repeat the gastric analysis frequently during medical



is recorded. The cases have been grouped into 4 classes, based upon the time elapsing between the beginning of treatment and the last examination. The data are summarized in Table III. The greater pro-



treatment. Our clinic routine calls for a repetition of the examination at three, six, twelve, eighteen and twenty-four months and then at least once a year indefinitely. Such data were available in



portion of these cases had an initial hyperacidity. The latter were segregated and studied as a separate group. Fifty-eight per cent of cases with hyperacidity showed a definite lowering of the acid level



TABLE III  
SUMMARY OF EFFECTS OF TREATMENT ON POSTPRANDIAL ACIDITY

Hyperacidity Cases						Recurrences		All Cases			Recurrences of Symptoms	
Time of Treatment	No. of Cases	Acidity Elevated Per Cent of Cases	No Change Per-centage	Acidity Reduced Per-centage	No. of Cases	Per Cent	No. of Cases	Acidity Elevated Per Cent	No Change Per-centage	Acidity Reduced Per Cent	Cases	Per Cent
3 to 6 mos.	12	25	17	58	0		19	47	16	37	2	10.5
6 to 12 mos.	8	25	63	12	3	37.5	10	40	50	10	4	40
1 to 2 yrs.	14	50	21.4	28.6	6	42	17	58.8	17.6	23.6	6	35.3
Over 2 yrs.	23	43.5	21.7	34.8	12	52	25	48	20	32	14	55
Summary of all cases	57	....	....	....	21	36.5	71	....	....	....	26	36.5

in from three to six months after the institution of therapy. Only 8 cases with hyperacidity were studied from six to twelve months after starting treatment. The acidity remained the same or was elevated in 7 cases. In a series of 14 hyperacid cases studied from one to two years after beginning treatment, the last acidity was reduced in 4, 7 had a higher acidity and in 3 the grade of hyperacidity was unchanged. In 23 hyperacid cases, the test was repeated from two to six years later. The acidity was reduced in 8 cases, remained the same in 5 but was elevated in 10. Three types of medical treatment were employed: the modified Sippy Hospital plan, peroral jejunal feedings and an ambulatory regimen. The change of acidity did not vary with the various types of treatment employed. An initial drop in gastric acidity may be expected in certain cases of duodenal ulcer with hyperacidity, a short time after the regimen has been instituted. This finding may be attributed to the relaxation of the pylorus and a lessening in the degree of hypersecretion. In two-thirds of the hyperacid cases re-examined after a period of two years or more no reduction of acidity occurred. The acidity either remained the same (21.7 per cent), or in a larger number of cases it was actually

elevated (43.5 per cent). However, the percentage of cases with reduced acidity was increased slightly but steadily after the lapse of one year. We doubt if the cases selected for this study are representative of our whole duodenal ulcer group. A great many of our patients, upon whom repeated examinations were carried out, were those who returned because of a recurrence of symptoms. On this account a record was made of the incidence of recurring ulcer symptoms in the cases used in Table III. The findings are of decided interest. A steadily increasing incidence of recurrence was noted as the lapse of time after treatment was increased. Ulcer symptoms recurred in 10 per cent of the cases in which the fractional test was performed from three to six months after starting treatment; in 40 per cent from six to twelve months; in 35 per cent from one to two years and in 55 per cent after two years. The incidence of recurrence is not related to the grade of acidity. A recurrence of symptoms developed in 5 of 14 cases with an original normal or subnormal acidity. However, in 19 of the cases with recurrences, the acid level at the time of the recurrence was higher than it was originally. One might infer that the height of acidity had nothing to do with the incidence of recur-



TABLE IV

GRADE I. HYPONOTILITY BY GASTRIC ANALYSIS—COMPARED WITH RETENTION BY X-RAY (58 CASES) (29 PER CENT)

Case Number	Quantity of Juice (C.c.) (Fast-ing)	Quantity of Food (C.c.) (Fast-ing)	Quantity 2 Hr. Juice (C.c.)	Quantity 2 Hr. Food (C.c.)	Quantity X-ray Retention, Per Cent	Case Number	Quantity of Juice (C.c.) (Fast-ing)	Quantity of food (C.c.) (Fast-ing)	Quantity 2 Hr. Juice (C.c.)	Quantity 2 Hr. Food (C.c.)	Quantity X-ray Retention, Per Cent
188	50	0	130	4	0	174	45	0	30	10	0
190	100	0	15	1	0	179	60	0	Empty		
2	170	0	.....	..	30	181	70	0	15	1	
7	60	0	30	2	0	182	100	0	16	2	
11	45	0	25	5		184	60	0	20	5	0
12	70	0	10	0	0	186	60	0	30	5	0
13	120	0	10	5	10	187	45	0	40	6	0
16	50	0	45	0	0	74	55	0	10	1	
20	50	0	8	0	0	75	75	0	30	0	0
21	50	0	80	2		77	60	0	5	0	0
22	83	0	10	2		78	40	0	30	2	10
23	20	0	80	3	10	80	50	0	15	1	30
26	95	0	80	10	10	84	45	0	15	8	40
30	80	0	10	3	0	85	85	0	8	0	20
32	80	0	10	4	0	88	Not ob- tained	..	20	6	0
38	18	0	40	4		89	80	0	Empty	..	0
55	60	0	4	1	0	95	60	0	40	3	0
65	45	0	45	3	0	99	50	0	6	1	10
67	39	0	45	10		109	No res.	..	20	2	10
69	75	0	25	0		110	60	0	6	2	0
70	60	0	30	1		118	50	0	3	0	0
153	50	0	10	4		126	50	0	8	2	25
155	25	0	65	5		131	35	0	25	3	
159	150	0	5	1	26 plus	140	45	0	50	4	0
160	Not ob- tained	..	45	10		141	10	0	55	0	0
167	10	0	30	15	0	142	45	0	60	12	0
169	70	0	10	3	0	143	40	0	75	0	
170	60	0	Empty	..	0	144	90	0	30	10	0
172	50	0	Empty	..	0	149	50	0	20	1	

rence, but that a mounting acidity on subsequent examinations favors the likelihood of a recurrence.

Thirty-six and five-tenths per cent of 71 cases studied developed a return of ulcer symptoms. The percentage of recurrences is lower for the entire series of 200 cases. Many of the patients used for the study of the effect of medical treatment on acidity were of necessity those who developed subsequent trouble. It remains questionable therefore whether we are justified in concluding that a reduction in acidity two years after medical treatment occurs only in one-third of all cases of duodenal ulcer. It is likely that if a series without recurrences for three years

were studied that a greater proportion would show a reduced acidity. One cannot escape the fact, however, that medical management does not materially reduce the gastric acidity in the majority of cases.

#### MOTILITY

Delayed motility was estimated by an examination of the fasting overnight residuum and the two-hour extraction. In the fasting residuum the criteria of hypomotility are: an excessive quantity of juice, the presence of microscopic food or gross food. Rehfuess, Bergeim and Hawk<sup>9</sup> consider 50 to 80 c.c. the upper limits of normal. We consider a quantity above 50 c.c. to be abnormal. Two hours after

TABLE V  
GRADE II. HYPOMOTILITY BY GASTRIC ANALYSIS—  
COMPARED WITH RETENTION BY X-RAY (39  
CASES) (19.5 PER CENT)

Case Number	Quantity of Juice (C.c.) (Fast-ing)	Quantity of Food (C.c.) (Fast-ing)	Quantity 2 Hr. Juice (C.c.)	Quantity 2 Hr. Food (C.c.)	Quantity X-Ray Retention Per Cent
72	40	Gross	45	20	40
76	90	Gross	50	10	24 hour retention
79	180	Gross	110	25	50
106	6	Gross	6	0	0
117	15	Gross	90	3	10
127	50	Gross	12	4	
129	50	0	50	10	
132	60	0	100	20	
133	45	0	50	20	
147	40	0	80	30	
150	70	0	80	50	20
148	Not obtained	.....	135	50	0
151	50	0	50	10	20
152	90	0	65	15	
162	30	Gross	50	25	50
163	40	0	100	75	10
164	45	0	90	45	0
165	40	0	110	75	0
166	30	0	100	85	10
168	100	0	120	60	0
173	60	0	80	35	0
176	60	Gross	85	85	10
177	110	0	50	20	
200	20	0	70	40	0
9	80	0	30	20	
17	60	Gross	12	0	0
27	13	0	35	25	0
31	90	0	80	50	0
33	65	0	110	10	0
34	30	Gross	300	100	
36	105	Gross	150	25	
37	60	0	90	30	
39	45	0	250	50	0
58	45	0	105	15	10
59	120	0	70	20	
60	150	0	150	10	24 hour retention
66	30	0	40	20	50
68	25	0	105	30	
111	15	0	80	20	

on gastric motility. Bell and MacAdam<sup>11</sup> have shown that the rate of stomach emptying of a test meal was a remarkably constant feature in the normal individual. Their observations were checked by roentgenologic examination. A quantity of fluid in excess of 50 c.c. or more than 10 c.c. of food in the two-hour extraction was taken as evidence of impaired motor function. Various combinations of these signs of delayed motility were found in different cases. For purposes of discussion a simple classification into 3 grades of hypomotility was made.

Cases having 50 c.c. or more of fasting juice without food or more than 50 c.c. of digestive juice with or without slight food retention at two hours were classified as Grade I hypomotility. There were 58 cases or 29 per cent in this group (Table IV). Forty-three of them had less than 5 c.c. of food sediment remaining in the two-hour extraction. In the latter (21.5 per cent of the whole series), hypersecretion alone may have accounted for the apparent delay. In most of them from 50 to 100 c.c. of fasting juice were present and from 25 to 100 c.c. of juice were removed at two hours.

Grade II motor delay includes cases showing in addition to an excessive fluid content microscopic food in the fasting residuum or a quantity of food sediment at two hours in excess of 20 c.c. or both. Thirty-nine cases (19.5 per cent) were so classified (Table V).

In the Grade III hypomotility group we included all cases with overnight fasting gross food retention regardless of the other criteria of delay which may have been present. In most instances the quantity of juice in the fasting residuum and in the two-hour extraction was in excess of that found in Grade II. There were 11 cases in this group or 5.5 per cent (Table VI). Evidence of delayed motility was revealed by the fractional gastric analysis in 108 of 200 cases of duodenal ulcer or 54 per cent. The prevalence of delayed gastric evacuation in duodenal ulcer is further

the ingestion of the meal, the stomach was carefully emptied. Lyon<sup>12</sup> has drawn attention to the importance of completely emptying the stomach at the last extraction and suggested the use of a test lavage after the stomach has been emptied as a check

TABLE VI  
GRADE III. HYPOMOTILITY BY GASTRIC ANALYSIS—  
COMPARED WITH RETENTION BY X-RAY (11  
CASES) (5.5 PER CENT)

Case Number	Quantity of Juice (C.c.) (Fast-ing)	Quantity of Food (C.c.) (Fast-ing)	Quantity 2 Hr. Juice (C.c.)	Quantity 2 Hr. Food (C.c.)	Quantity X-Ray Retention, Per Cent
191	70	Gross	40	10	0
198	50	Gross	10	1	25
15	340	50	230	100	50
35	630	105	160	3	50
40	50	Gross	250	40	24 hour retention
57	60	Gross	8	1	
62	150	Gross	150	45	0
180	80	Gross			
185	1500	Gross	120	80	70
81	120	30	210	100	26 plus
82	1300	400	400	50	50

shown by the fact that 67 c.c. were found to be the average amount of residuum in the entire series of 200 cases. The incidence of hypermotility was very low. The test meal had completely left the stomach ninety minutes after the ingestion in only 5 cases, 2.5 per cent of 200 cases. The motility was considered to be normal in 87 cases (43.5 per cent).

#### DELAYED MOTILITY BY GASTRIC ANALYSIS COMPARED WITH RETENTION BY ROENTGEN-RAY

Unfortunately data were not available in every case; only those cases are included in which a definite statement regarding the amount of retention was made in the radiographer's report or in which personal inspection of the six-hour film was made by one of us.

Grade I delay by gastric analysis was present in 58 cases. In 41 of them roentgen-ray data were also available. Only 12 cases had six-hour retention. It is noteworthy that 70 per cent of cases having Grade I delay by gastric analysis showed no evidence of retention at six hours by roentgenogram.

Grade II delay by fractional method was

present in 39 cases. Roentgen observation of retention was made on 26 of them. In 13 cases or 50 per cent barium retention was absent.

Gastric analysis showed Grade III retention in 11 cases. Roentgen-ray data were available in 10. In this group the two methods under discussion reveal similar results. Only 2 failed to show barium retention at six hours. As the degree of retention by gastric analysis increases the frequency of roentgen-ray retention is greater. In the Grade III hypomotility group, 80 per cent also have retention by roentgen-ray. Only 30 per cent barium retention was present in the Grade I group. Several factors may be offered as an explanation for the absence of parallelism between the two methods. The delay in many of the Group I cases may have been due to hypersecretion rather than hypomotility. A more likely explanation is the presence of a grade of delay insufficient to cause a six-hour residue but nevertheless considerably greater than normal. It is our feeling that the ingestion of a small natural food meal is a better test load. One can judge the degree of motility better by emptying the stomach at a definite period and accurately measuring the residue. The roentgenologic method in vogue gives no information of the stomach's activity during its more active motor phase from one to three hours after the ingestion of the meal.

Roentgenologic six-hour observations were carried out in 77 of the 108 cases having delayed motility by gastric analysis. Less than half of these 77 cases (43 per cent) had barium retention at six hours.

#### ROENTGENOLOGIC RETENTION COMPARED WITH DELAYED MOTILITY BY GASTRIC ANALYSIS

The degree of retention of barium was classified into 3 groups. Retention up to 10 per cent at six hours was designated Grade I, from 11 to 25 per cent Grade II, and 26 per cent or above at six hours or twenty-four hour retention, Grade III. Evidence of roentgen-ray retention was

present in 44 of 147 cases (30 per cent). Grade I barium retention was present in 14 cases, Grade II in 14, and Grade III in 16. Two Grade III cases emptied normally by gastric analysis or 12.5 per cent. Five cases or 36 per cent of the Grade II group failed to show hypomotility by the fractional method. Gastric analysis did not reveal retention in 29 per cent of the 14 cases with Grade I roentgen delay. In the entire group of 44 cases with roentgenologic evidence of retention, 11 cases or 25 per cent showed no hypomotility by the food meal.

Fifty-four per cent of 200 cases with duodenal ulcer had motor delay as determined by its fractional gastric analysis. The barium meal gave evidence of retention in only 31 per cent of cases in the entire group. Regardless of the manner in which these statistics may be viewed, one cannot escape the conclusion that the fractional gastric analysis is more accurate measure of the motor function of the stomach than the commonly performed six-hour roentgenologic observation.

#### EFFECT OF MEDICAL TREATMENT ON MOTILITY AS DETERMINED BY GASTRIC ANALYSIS

**CASES RE-EXAMINED ONE TO THREE MONTHS AFTER TREATMENT.** Data were available in 13 cases. Seven cases showed normal motility after treatment. There was no change in gastric motility in the remaining. A return to normal motility occurred in 54 per cent of this small group of cases.

**GASTRIC ANALYSIS REPEATED AFTER THREE TO TWELVE MONTHS.** In a series of 19 cases improvement in motility occurred in 8 and normal emptying was present in 3. It is noteworthy that 14 cases studied during this period after treatment had moderate to marked degrees of retention previous to treatment. Fifty-eight per cent of the series showed a lessening of retention after treatment but only 16 per cent showed normal motor function.

**RE-EXAMINATION AFTER ONE TO FIVE YEARS.** Eighteen cases were studied after

a one-year period, the majority from two to five years. A decrease in the grade of retention was noted in 7 cases and a return to normal in five. The degree of delay remained the same or was greater in 6 cases or 32 per cent. Sixty-eight per cent had less retention when studied from one to five years after treatment.

Fifty of 200 cases of duodenal ulcer with delayed motility had a second gastric analysis performed at periods varying from two months to five years after medical treatment was first instituted. The last gastric analysis showed improvement in stomach emptying in 15 cases and normal motility in fifteen. Forty per cent had no reduction in the degree of gastric retention. It has been our experience that no further improvement in motility occurs in cases with retention after the first three months of medical treatment. If the gastric analysis at that time reveals retention of Grade II or more, which can be attributed to the duodenal ulcer, a permanent cure should not be expected by medical treatment. The element of pylorospasm has been largely eliminated and the residual delay in emptying is dependent upon some degree of pyloric obstruction. The extraction of the morning fasting residuum while the patient is on a modified Sippy regimen only indicates the stomach's ability to empty a liquid test load after twelve hours. The quantity of the fasting residuum may be markedly reduced on such a diet after two weeks of hospitalization, but the fractional test with bread as a test load will reveal marked retention in the two-hour extraction. If the fractional gastric analysis continues to show considerable motor delay after six weeks of a strict medical regimen surgical treatment is indicated.

#### PATHOLOGICAL PRODUCTS

**Bile:** The relationship between duodenal regurgitation and gastric acidity has been the subject of much discussion. However, the presence of bile in the fasting and digestive phases of the fractional gastric

analysis has received scant attention as an index of pathology in the neighborhood. Very little is to be found concerning the incidence of biliary regurgitation in duodenal ulcer. Gross bile was noted in the fasting residuum in 78 of 200 cases of duodenal ulcer in this series or 39 per cent. Because of our failure to recover bile from the fasting stomach with any frequency in so-called normal individuals, we attribute some significance to the high incidence of this finding in duodenal ulcer. Our observations confirm those of Lyon, who believes that frank macroscopic biliary regurgitation into the fasting stomach suggests some functional derangement at the pylorus. Duodenal regurgitation into the fasting stomach was not based upon a single observation in many cases. A number of patients while in the hospital had fasting residual extractions made repeatedly. Bile reflex was noted to be a consistent phenomenon in many of them. Because of the interest manifested in the relation of duodenal regurgitation to gastric acidity, a comparison was made between the fasting residues, with and without bile. The result of this comparison is of interest. A decided hyperacidity was present in 74 per cent of the fasting contents containing gross bile. Only 56 per cent of the fasting contents without bile were hyperacid. Boldyreff<sup>13</sup> and many others consider biliary regurgitation into the stomach a normal finding in hyperacidity. It is quite possible that the high incidence of biliary regurgitation in this series may merely be dependent upon the hyperacidity. It is equally probable that the disturbance of the pyloric mechanism responsible for the bile reflux is due to an irritable focus in the duodenum, independent of the level of gastric acidity. Since 25 per cent of the cases with bile did not have hyperacidity, a figure analogous to the absence of hyperacidity in the whole series, one might assume that the biliary reflex is dependent upon the duodenal ulcer rather than upon the hyperacidity. Regardless of the interpretation placed upon the analysis, biliary regurgitation into the fasting stomach occurs much

more frequently in patients with duodenal ulcer than in patients without pathology in the neighborhood.

A record was also made of the incidence of biliary regurgitation in the postprandial extractions. In 36 cases bile was present in 4 or more extractions, an incidence of 18 per cent. Seventy-five per cent of cases with postmeal bile reflux were hyperacid, whereas 85 per cent of bile-free cases had a hyperacidity. The average grade of hyperacidity in the latter group was higher than in the cases with bile. The presence of bile during the second phase of the analysis is sufficient to substantially reduce the degree of acidity in some cases. Its appearance may merely be an attempt at neutralization because of the hyperacidity and in no way dependent upon the ulcer. At any rate it is responsible for lowering the incidence of hyperacidity in duodenal ulcer. Of practical importance is the fact that biliary regurgitation into the fasting and digestive stomach occurs more frequently in duodenal ulcer than in normal individuals.

*Occult Blood:* Only 28 cases in the entire series of 200 cases gave sufficiently marked reactions with benzidine to be considered positive. In the carrying out of the test for occult blood, the filtrate was used. This eliminates the blood contained in large mucoid masses which have been swallowed as a result of trauma in the swallowing of the tube. In estimating the presence of occult blood, the possibility of traumatizing the mucosa in making the extractions must be considered. If extractions are difficult to obtain, no attention should be paid to a positive benzidine test. A moderately quick color change in fractions which were removed with ease are of decided importance. The presence of occult blood only in those fractions which contain bile is most suggestive of a bleeding duodenal lesion, as Rehfuess has suggested. Only 14 per cent of our cases had positive reactions with benzidine in the gastric fractions. The finding of occult blood in the gastric extractions, particularly if they contain bile is favorable to a

diagnosis of duodenal ulcer. A negative extraction of course does not militate against such a diagnosis, as only a small proportion of cases will give a positive test.

#### SUMMARY

The fractional gastric analysis has been subjected to a critical review in 200 carefully selected cases of duodenal ulcer. The fasting residuum in many cases is characteristic. The quantity of the residuum is greater than normal, averaging 67 c.c. It might be described as a thin, watery opalescent fluid often having a faint greenish or bluish tint. In 39 per cent of cases the residuum contained gross bile, a much greater incidence than in normal individuals. Fifty-seven and five-tenths per cent of cases had a fasting hyperacidity. Biliary regurgitation probably reduced this figure somewhat. The average fasting acidity was: hydrochloric acid, 28; total acidity 42.4.

A postprandial hyperacidity was present in 84 per cent of cases. This percentage is slightly higher than any previous series reported. Because of the size of this series, we feel it more nearly represents the actual acidity in patients having duodenal ulcer who have not been subjected to operation. The finding of subnormal acidity is so infrequent (8 per cent) in duodenal ulcer that one should hesitate before making a positive diagnosis of ulcer of the duodenum if the acidity is subnormal. The type of acid curve with a terminal ascent originally described by Rehfuess was present in the great majority of cases. This is of decided diagnostic import.

The review stresses the significance of delayed motility as determined by the fractional analysis in study of the patient with duodenal ulcer. Hypermotility was very infrequent, occurring in only 2.5 per cent of cases. One hundred and eight cases (54 per cent) showed various grades of motor delay. The importance of examination of the two-hour extraction as well as the fasting residuum from the standpoint of motor delay is shown. The increase

in the quantity of fasting juice or the presence of microscopic or gross food in the overnight residuum has been stressed by many observers. Very little attention has been given to the determination of motility at two hours. In many instances the hypomotility is insufficient to cause an excessive quantity of morning residue but the stomach will be unable to evacuate a normal test load within the two-hour period. A normally emptying stomach should contain less than 25 c.c. of fluid and 5 c.c. of food sediment two hours after the ingestion of the test meal. For purposes of analysis we considered 50 c.c. of juice and 10 c.c. of food the upper limit of normal.

That the fractional gastric analysis carried out as described is a more delicate measure of gastric motor impairment than the ordinary six-hour roentgenologic observation is obvious from the study. Gastric retention by the fractional analysis was present in 54 per cent of cases. Thirty-one per cent had evidence of retention by barium meal. A common practice of interpreting a fractional gastric analysis in terms of acidity only and ignoring the evidence of motor insufficiency is to be deplored. The test is the most reliable method of testing the motor function of the stomach in routine clinical practice.

Bile in the fasting stomach is a frequent finding in duodenal ulcer. It was present only in the fasting residue in 51 cases. Thirty-six additional cases had bile in more than 4 of the postmeal fractions. The fasting contents containing bile were more often hyperacid than the residuums free from bile. It seems probable that the presence of the duodenal ulcer may be responsible for the bile reflux independently of hyperacidity. The postprandial acidity is lower in the group of cases with bile than in the bile-free cases, probably due to the factor of neutralization. The percentage of cases of duodenal ulcer with hyperacidity would probably be greater if it were not for this tendency to biliary regurgitation. We are convinced that the incidence of biliary regurgitation is much

greater in duodenal ulcer than in individuals without disease in the pyloro-duodenal region.

The literature contains very little of value bearing on the effect of medical treatment in cases of duodenal ulcer as determined by the method under discussion. The test was repeated in many cases at varying intervals after the institution of recognized methods of medical treatment. The incidence of cases having an ulcer relapse is recorded. The degree of gastric acidity seems to bear no relationship to the tendency to recurrence of symptoms. That is, relapses were not more frequent in cases showing extreme hyperacidity at the time of original examination than in cases with lesser grades of acidity. However, if repeated examinations show a tendency for the acidity to mount even higher, a recurrence should be anticipated. The majority of cases showing this tendency developed a return of symptoms.

Frequent fractional tests for the determination of gastric motility are of decided importance in prognosis and of great assistance in making a decision as to the method of treatment to be employed. During the active stage of treatment, examinations of the fasting residuum may show a gradual reduction in quantity, even approximating the normal. At the same time the fractional test meal will show a persistence of gastric motor delay. If after four to six weeks of a strict hospital regimen, the fractional test shows a Grade II or greater delay, medical treatment is doomed to failure and surgery had better be advised.

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#### DISCUSSION

DR. SMITHIES: The interesting thing about these cases, to me, is the fact that 200 cases can be diagnosed correctly, without any previous surgical interference. Frankly, I wonder if we are dealing with that kind of ease. There are several changes in motility which we come into contact with. The stomach can tie itself into knots: that is hypermotility; then there is hypomotility, where it can scarcely move at all; here, there is a change in emptying time.

I thought it was pretty well understood all over the United States that if one wishes to get the best result, he should give barium with real food, and a meal. Food is a good menstruum for this substance and you should take advantage of that, instead of just giving patients a pitcherful of this none-too-tempting looking substance to swallow, and introducing a mass of barium which is heavier to move than food, and might have a different effect on different individuals, as you know, depending upon the musculature and a great many other incidental factors as secretion in that stomach. It is certain that these test meals of barium should be administered with food. I should like to know, also, if we do not sometimes make a mistake in estimating the acidity, here, with a test meal of food which the stomach is not accustomed to digesting. The stomach is devoted to the digestion of protein, and not to carbohydrates and yet most test meals are carbohydrate. Acidity figures mean nothing unless they are translated into terms which



we can understand. In other words the question is, are we dealing here with acute ulcers, with chronic, or with perforating ones. Surely the character of the pathologic process makes a difference in the acid-value returns: Are the essayist's figures just a cross-section of several kinds of ulcer or a statement of the condition that any ulcer may attain in time?

DR. A. F. R. ANDRESEN: I am very glad that Dr. Bockus has again called attention to the importance of fractional gastric analysis. I wish to emphasize its value in the diagnosis of duodenal ulcer, in which disease it is, I believe, of greater diagnostic value than any other procedure, especially in cases in which history suggests an ulcer, and the roentgen ray shows a deformity of the duodenal cap, but no definite area of defect or protrusion. If in the course of the fractional analysis, after the tube has been in the stomach for an hour or more and no occult blood has been found in any specimens, there suddenly occurs the normal reflux of bile-stained duodenal contents into the stomach, and coincident with this there are found small red or brownish floccules, giving a powerful occult blood reaction, it is certainly safe to say that there is an area of bleeding in the duodenum. This is almost sure to be due to an ulcer, although rarely a carcinoma or the injury caused by passage of a gallstone may produce a similar finding. In gastrojejunal ulcer the method is also diagnostic, and I know of no other method that gives us as valuable an indication of the healing of an ulcer. With the use of histamine as a secretory stimulant, and water as a test of motility, and preceded by an examination of fasting contents after a rice and raisin meal, the time consumed in making the fractional analysis is fully justified because of the information obtained.

DR. FRIEDENWALD: In 1920, Dr. Morgan and I published our results on the fractional analysis in cases of duodenal ulcer. We observed that the acidity usually rises higher than in any other condition. It reaches its height rapidly, there is then a fall and a secondary rise, or there may be a continuous prolonged rise from the onset. This rapid rise as well as the secondary rise is rarely observed except in ulcer. In our 34 duodenal ulcer cases hyperacidity was present in 25 and normal acidity in 9; and the highest acidity appeared after an hour in 11 cases and in the hour in 15

cases. It is therefore evident that in the 15 cases, the highest acidity would have been entirely overlooked had one depended upon the hour examination alone. At times, blood is obtained in the contents after the end of an hour. This finding lends additional evidence as to the presence of an ulcer and in doubtful cases may clear up the diagnosis. Inasmuch as the duodenal tube does not pass beyond the stomach into the duodenum there can be little question of trauma in these cases. Rapid evacuation of the stomach contents occasionally occurs but more frequently delayed motility due to pylorospasm.

My experience is also in accord with that of Dr. Aaron in that one should hesitate to advise operation for pyloric retention based on gastric analysis and x-ray study alone without a further study of the case. In a number of instances of this type, as we have shown in a recent paper,<sup>1</sup> retention may only be transitory and may be overcome by means of appropriate medical treatment.

DR. BOCKUS (*closing*): The discussion of test meals as they relate to gastric acidity is not pertinent to the subject matter of this paper. The study of both acidity and motility followed the usual bread and water meal, and comparison is made with the usual food mixture and opaque salt used in x-ray laboratories throughout the country.

I am sorry that a wrong impression has been obtained regarding the material selected for study. I am not stating and have not stated that our diagnosis of duodenal ulcer is 100 per cent accurate. The cases were as carefully selected as it is possible without operative check. The cases were all studied originally during the active stage, and had the characteristic classical symptomatology and roentgenologic evidence of duodenal ulcer.

With regard to the remarks on delayed gastric emptying, I want to state it is not our feeling that every case with delay should be surgically treated. Surgery is recommended in those cases in which a Grade II or greater delay in gastric emptying persists after six weeks of rigid medical management. The wisdom of this plan is borne out in our cases of duodenal ulcer, the great majority of which have eventually come to surgery if this degree of retention has persisted after several weeks of medical management.

<sup>1</sup> *South. M. J.*, 22: 431, 1929.



# ACUTE PERFORATING PEPTIC ULCER

A REPORT OF 21 CASES WITH REVIEW OF 933 CASES REPORTED BY THIRTEEN AUTHORS DURING THE LAST TEN YEARS\*

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TWO years ago we presented a follow-up study, covering a period of from two to ten years, of 100 patients surgically treated for peptic ulcer; and of 100 patients medically treated for peptic ulcer. At that time our total series of peptic ulcer diagnoses included 14 acute perforations; since then we have added 7 more, a present total of 21 patients diagnosed and operated upon for acute perforation in a series of 445 patients diagnosed as having peptic ulcer. So far we have not seen perforation occur after a diagnosis of peptic ulcer has been made and advice given; nor have we seen any patient suffering from acute perforation who had had a previous diagnosis of ulcer made elsewhere.

*Location of Perforations.* Five patients had perforations of gastric ulcers; 16 patients had perforations of duodenal ulcers. Eighteen of 21 perforations occurred on the anterior or superior surface of the duodenum or on the anterior surface or lesser curvature of the stomach, all close to the pylorus.

*Age and Sex* are shown in Chart 1. Two-thirds of all perforations occurred between the ages of thirty and fifty years.

*Clinical Histories.* Two dying patients and one foreigner were unable to give histories. All other patients gave a history typical or suggestive of ulcer; yet in several instances the history was not obtainable until after operation. The critically ill and suffering patient gives a poor history of previous digestive disturbances, considered too mild to tell about or else forgotten during his terrific and sudden agony.

A striking point in the clinical histories as tabulated is that 6 only of 18 patients on whom histories were obtained were having stomach trouble immediately previ-

ous to perforation. Twelve patients were relatively or absolutely symptom-free at the time of perforation. The catastrophe came without warning and without previous clinical diagnosis of ulcer.

One patient suffered from an acute perforation after two days of repeated massive hemorrhage.

## FOLLOW-UP STUDY

Three postoperative deaths occurred:

1. A woman aged seventy, operated on within six hours, who died apparently from shock.

2. A woman aged fifty-five, operated on four days after perforation in vain hope of relief.

3. A man aged forty-two, operated on after four days, likewise in a hopeless attempt to rescue a dying patient.

A gross mortality of 15 per cent occurred in our series.

Eighteen patients survived operation and have been followed to date.

Four had gastroenterostomy done at the time of suture, all survived operation, and 3 are symptom-free.

Fourteen patients survived simple suture of the acute perforation. Of these, 9 are symptom-free; 2 are having symptoms enough to require gastroenterostomy; 3 have required secondary gastroenterostomy, with relief.

Eight patients have recently returned by request for x-ray examination; all present deformities at the present time, regardless of symptoms.

It is worth noting again that no patient having an acute perforation had had a previous diagnosis of ulcer, and that most patients had not previously consulted a physician for indigestion. Further, in our

\* Read at the 33d Annual Meeting of the American Gastro-Enterological Association, Atlantic City, May 6, 1930.

100 medical cases followed for from two to ten years we have found no instance of acute perforation. Such facts bear out the

tabulated the results of 13 authors in various surgical services who have reported statistical results in series of cases. The

ACUTE PERFORATED PEPTIC ULCER						
Statistics—21 Patients						
Mortality Record—21 Cases.....				Age	Cases	
	12 h	12-24 h	+24 h			
Cases	14	3	4	20-29		1
Deaths	1	0	2	30-39		5
				40-49		9
				50-59		5
				60-70		1
Follow-Up Study						
18 Cases ..						
Result	Satisfactory	Poor	Re Opr.	Sex	Cases	
Gast Ent.	3	1	0	Male		19
Closure	9	2	3	Female		2

CHART I.

internist's experience, that any reasonable medical care is excellent assurance against acute perforation at any subsequent time. Occasionally surgeons have reported per-

ACUTE PERFORATED PEPTIC ULCER									
Collected PERCENTAGE Results after Operation									
PERCENTAGE		Authors...		Deaths		Good		PERCENTAGE	
by Results	by Results					by Results	by Results	by Results	by Results
12	22	67	EVANS			+	0		
		12	41	SMITH					
		18	149	DANSEY					
20	72	29	158	WILLIAMS & WALSH	102	29	57	3	
27	50	29	62	MEYER & BRAMS					
6	66	75	32	MCGLENNAN & BONGARDT	14	78	15	7	
		18	50	MORRISON					
0	0	100	8	24	STEWART & BARBER	+	0		
0	40	77	19	59	POOL	36	67	11	22
6	60	100	25	24	MCCREERY	18	55	22	22
12	15	60	89	123	GIBSON	83	77	1	22
15	25	74	29	68	STENBUCK & LEWISOHN	33	68	23	12
		15	60	FLATOU	41	54	20	20	7
7	0	50	15	21	BLACKFORD & BAKER	18	61	21	17
					TOTALS	253			
15	32	71	72	.....	Average Percentages	68	12	20	3

\*44 of 57 routine delayed G.E.

CHART III.

British authors report large numbers of cases; Dansey reports 149 from Australia on whom he has personally operated.

**Sex Incidence.** Tabulation of 954 case reports shows that only 43 patients were females. This astounding ratio of 43 females to 911 males, or 1 to 21, is to be considered in relation to the 1 to 3 ratio, or thereabouts, of peptic ulcer found in females. The female patient suffering from peptic ulcer is less than one-fourth as liable to acute perforation as the male patient having peptic ulcer.

**Mortality Records.** All authors agree that up to six hours the patient's chances for recovery are excellent and up to twelve hours are good. Several rather large series report no deaths if the operation took place within twelve hours. Three hundred twenty-one patients operated on within twelve hours of acute perforation show a mortality of 15 per cent. The average risk more than doubles during the second twelve hours, 58 cases showing a mortality of 32 per cent. After twenty-four hours the rate in 83 cases rises to more than 70 per cent.

Stenbuck brings out that the deaths fall into three definite groups:

1. Deaths in the first two days after operation, apparently due to peritoneal shock.

954 Collected Cases						
ACUTE PERFORATED PEPTIC ULCER						
SEX	Authors		Deaths	OPERATION		
M. F.				G.E.	Closure	
67	0	EVANS	15	57	10	
40	1	SMITH	5	0	41	
130	19	DANSEY	26	56	93	
152	6	WILLIAMS & WALSH	46	0	158	
62	0	MEYER & BRAMS	18			
27	1	MCGLENNAN & BONGARDT	9	1	27	
50	0	MORRISON	9	33	17	
20	4	STEWART & BARBER	2	0	24	
58	1	POOL	11	9	50	
23	1	MCCREERY	6	6	17	
118	5	GIBSON	23	7	115	
86	2	STENBUCK & LEWISOHN	24	28	60	
59	1	FLATOU	9	15	44	
19	2	BLACKFORD & BAKER	3	4	17	
911	43	TOTALS...	206	216	673	

\* Advocate Primary Gastro-Enterostomy

CHART II.

forations occurring during or following medical treatment or following x-ray examination, but such accidents are evidently unusual.

#### SUMMARY OF COLLECTED CASES

We have reviewed the English and American literature for ten years back and

2. Deaths in six to ten days, due to general peritonitis.
3. Deaths after ten days, due to late

*Follow-up Study.* Two hundred fifty-three cases followed by 8 authors show that 68 per cent are relieved, 12 per cent con-

ACUTE PERFORATED PEPTIC ULCER	
5 Authors advocate usually doing—	
<b>PRIMARY GASTRO-ENTEROSTOMY</b>	
350 Cases	
167 Gastro-Enterostomy (48%)	
65 Deaths <b>MORTALITY 18.6%</b>	
8 Authors advocate usually doing—	
<b>PRIMARY SIMPLE CLOSURE</b>	
542 Cases	
49 Gastro-Enterostomy	
123 Deaths <b>MORTALITY 22.7%</b>	

CHART IV.

ACUTE PERFORATED PEPTIC ULCER		Collected Late Results in PERCENTAGES	
Closure Only	Authors	Primary G. Ent.	Ent.
PERCENTAGES		Number	PERCENTAGES
Number		Number	
Followed		Followed	
78 22 3 58	WILLIAMS & WALSH	44 56	5
78 15 7 14	M'GLANNAN & BONGARDT		
68 10 23 31	POOL	5 80 20 20	
50 16 33 12	MC CREERY	6 66 33	
77 1 22 2 83	GIBSON		
48 28 14 21	LEWISOHN	12 63	17
23 31 31 12 26	FLATOU	15 100	
57 22 22 14	BLACKFORD & BAKER	4 75 25	
	TOTALS	42	
66 12 22	Average PERCENTAGES	83 77 21	

CHART V.

abscess complications, such as liver abscess, subphrenic abscess, empyema, etc.

*Age and Mortality.* Stenbuck shows in his series that the death rate rises with age; yet Williams and Walsh in a much larger series state that the age of the patient is not any particular factor in recovery. Combining into decades the mortality rate of 290 cases reported by Stenbuck, Williams, McCreery, and ourselves we find that mortality increases with age. Half of all acute perforations occur in the fourth and fifth decades.

*Secondary Perforations* have occurred after simple suture, yet only 8 instances (less than 1 per cent) are reported in the papers covered in this study, reporting 585 simple closures.

Certain patients seem to have an "ulcer forming tendency" and require repeated operations in the attempt to find relief. Several authors describe series of operations on such cases; and some of the patients are not yet well.

The more radical procedures advocated by some continental writers have not appeared in our literature or in the authors' experience.

*Massive Hemorrhage* is rare at the time of acute perforation. We have seen it in 1 instance; very few are described. Slight hematemesis, however, is quite common.

tinue to have trouble, and 20 per cent come to a secondary operation.

#### IS PRIMARY GASTROENTEROSTOMY ADVISABLE?

Closure of the perforation is of course the first consideration. There is still much difference of opinion as to whether a primary routine gastroenterostomy should be done. Guthrie's questionnaire, answered by a large number of prominent American surgeons in 1923, showed that 22 believed in a routine gastroenterostomy, 64 never performed a primary gastroenterostomy, and 63 qualified their answers.

*Mortality.* It is said that primary gastroenterostomy does not add to the operative risk. Three hundred fifty cases, reported by 5 advocates of primary gastroenterostomy had 167 gastroenterostomies (48 per cent) with a gross mortality of 18.6 per cent. Five hundred forty-two cases reported by eight advocates of primary simple suture had 49 gastroenterostomies (9 per cent) done, and a gross mortality rate of 22.7 per cent. These figures show 4 per cent better operative mortality for primary gastroenterostomy.

*Morbidity.* We have tabulated the late functional results reported by 8 authors. Two hundred and sixty-nine cases treated by closure show only 66 per cent satis-

factory results; whereas 42 cases treated by closure with primary gastroenterostomy show 83 per cent satisfactory results. Late results are approximately 17 per cent better after gastroenterostomy.

It should be noted that the advocates of primary gastroenterostomy did this operation in only half their cases. They used their judgment on individual cases, and we may suppose that simple closure was usually done on critically ill patients.

Reports advocating primary gastroenterostomy are from lecturers at the Universities of Liverpool and of Sidney, and from the Boston City Hospital, Cook County Hospital of Chicago, and the Norwegian Hospital of Brooklyn. Reports advocating simple closure are from lecturers at the Universities of Liverpool and of Aberdeen, from Cook County Hospital of Chicago, from the New York Hospital, from Bellevue, and from Mount Sinai. Such sources, reporting hundreds of cases, must be presenting average similar cases.

Results seem to indicate clearly that primary gastroenterostomy is usually the method of choice if the patient is in good condition. The better immediate mortality reported must be due to better postoperative gastric function and drainage; for one would certainly expect the lesser operation to carry a lower mortality.

*Experimental Evidence.* Mann has shown that experimental operative procedures, essentially the diverting of the flow of alkalizing biliary secretions from the duodenum to the ileum of the dog, will always be followed by the development of duodenal ulcer. These experimentally produced ulcers are grossly and microscopically similar to human ulcers. Hemorrhages occur rather frequently, the bleeding usually coming from granulation tissue during a healing stage. Mann has shown further that the intestinal muscular coat destroyed by ulceration does not repair itself by filling in new muscle fiber, but leaves permanently a thin spot in the bowel wall. The new mucous membrane during healing creeps over very thin

delicate granulations; it is extremely smooth and thin and loosely attached to the underlying granulations; the mucous membrane does not grow into folds. This membrane is so delicate that it is easily washed off or wiped off in the cleaning of the specimen, so delicate that only special precautions will preserve such mucous membrane for study; hence it is usually not seen. Special technique is necessary to preserve it for microscopic study.

These experimental findings are of interest in view of the experience that ulcers in the human rarely have massive bleeding from an open vessel at the time of acute perforation. On the contrary, either hemorrhage or perforation is more frequent during a quiescent period, not infrequently even during sleep. The thin loosely attached new mucosa of ulcer healing apparently strips from the friable granulation base which has filled in the layer formerly occupied by smooth muscle, and in the quiescent stage no painful yet protective inflammatory reaction is present; hence a "blow-out" may occur through the peritoneum. Larger blood vessels, uninjured by inflammation, should not be affected by such a "blow-out." Such hypothesis explains "silent perforations" and "silent hemorrhages" well, and explains the usual lack of peritoneal reaction found at the site of perforation of peptic ulcer.

On the other hand, acute perforations do occur during severe and active symptoms of ulcer. This is less common because active erosion and inflammation boring through the viscus wall develops a protective localized peritonitis, which prevents or seals acute perforation. Such inflammation may, however, erode the wall of an artery, causing massive, even fatal, hemorrhage.

Theoretically, then, massive bleeding from an open vessel is far more likely to occur during severe ulcer symptoms; whereas perforation during severe ulcer symptoms is usually guarded against by nature's protective inflammatory wall. By

contrast, either moderate bleeding or perforation by "blow-out" is far more frequent during a quiescent stage of ulcer.

### CONCLUSIONS

In conclusion, we find from our own study and a review of 13 representative papers published in the last ten years:

1. Acute perforation of peptic ulcer occurs in a ratio of 1 female to 21 males, in comparison with the usual ratio of 1 female patient with ulcer to 3 male patients.

2. The gross surgical mortality in 954 collected cases shows: twelve-hour mortality, 15 per cent; twelve to twenty-four-hour mortality, 32 per cent; over twenty-four hour, 71 per cent. Gross mortality, all cases, 22 per cent.

3. Acute perforation of peptic ulcer almost never occurs in a patient who has ever had any kind of advice for treatment of peptic ulcer, or any previous diagnosis of peptic ulcer.

4. Massive hemorrhage is rare at the time of acute perforation, though slight hematemesis is common.

5. In our series, acute perforations have occurred in a quiescent stage of ulcer twice as frequently as during an active stage.

6. An explanation of the probable mechanism of "silent perforation" and "silent hemorrhage" of peptic ulcer is offered.

7. We find that advocates of primary gastroenterostomy, doing this operation in one-half of their cases, report 4 per cent better gross mortality and 17 per cent more satisfactory late results than do advocates of simple suture, doing but 9 per cent of primary gastroenterostomies.

8. Satisfactory results follow simple closure in 66 per cent of 269 cases, and follow primary gastroenterostomy in 83 per cent of 42 cases.

9. We advocate primary gastroenterostomy when the patient is a reasonably good surgical risk.

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# GASTRIC AND DUODENAL ULCER TREATMENT\*

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ANALYSIS of this subject by the faithful reader and patient listener, for an agreeable length of time, leads one to the consideration of three definite but somewhat overlapping issues. Firstly, there is the border warfare to establish a medico-chirurgical boundary line, a perennial parity conference, with the diplomacy not always in evidence. Secondly, there is a constant striving for standardization of procedure, an endeavor common to both medical and surgical interests. And thirdly, one observes the effort to express the last word, that one may slump back into the comforting embrace of the fully crystallized idea.

These curious small erosions of a slight fraction of man's vulnerable surface, a matter of indefinite consideration in past ages of medical knowledge, were subjected first to an intelligent anatomical and pathological consideration by Cruveilhier almost exactly a century ago. His treatment, compiled from his own observation and the experience of others, discloses that the modern method of non-surgical attack became authoritative at that time. In summarized form, he advocated twenty-four hours' abstinence from food, to be followed thereafter by several teaspoonfuls of milk every four hours, to be augmented later by gelatinous or starchy foods, gaseous waters and soups. He advised the use of calcined magnesia, carbonate of magnesia, lime water, peppermint tea and the sucking of sugar to promote salivary secretion. Note the early approval of the latest advances, namely, the superiority of calcium carbonate over alkalies that cause alkalization, the pharmacologic retardation of peristalsis by essential oils, and the utility of sugar as a salivary stimulant.

Expressing it briefly, for the requirements of this meeting, the proper non-surgical approach of the problem has been

in evidence, with slight variation, for a hundred years. The empiric principle of rest and frequent milk plus feedings, the reversion to the calcium of Cruveilhier, the abandonment of excessive alkalization furnish a program of contracted scope and limited variety comprehensible to everyone.

Experience in the so-called medical conduct of this condition has elicited valuable information on accompanying physical states, essential classificatory tabulations, differential diagnostic facts and proper appreciation of psychoneurotic influences.

But, from a long period of commendable application of the internist's virtues of patience, fidelity and persistence, we have received scant reward. A small group of cases, probably best described as possessing acute ulcers, show satisfactory response and fulfill requirements as to proper criteria of cure. This group perhaps substantiates the dictum that medical treatment should be given a trial in most newly discovered cases. But the great bulk of ulcers are of the chronic type with clear pathological characteristics. These all tend toward development of obstruction (34 per cent) gross hemorrhage (40 per cent) and perforation (6 per cent) in the duodenal area, plus malignancy in the gastric area. In weighing the value of the last factor one finds authority for any figure from 7 to 70 per cent. Regardless of whether this is a coincidental or causal finding, about 2 per cent of operations performed purely on evidence of gastric ulcer disclose the presence of malignancy.

Our medical measures consistently usually retard this progress, but eliminate pathology but rarely. With the result not often sufficiently appreciated or admitted, that we have under our care a more comfortable patient but a sick individual, a

\* Read at a meeting of the staff of the Rochester General Hospital, February 25, 1930.

slave to forms and times of eating, drinking, sleeping and defecation, a person to whom the elemental joys of living are restricted painfully, while the sword of Damocles hangs over his or her pylorus.

Thus, owing to concomitant, if not causal relationship of disturbed alimentary function, possible focal infection factors, vagotonic states, and social and mental problems, and due to occasional striking response or surgical contraindications some few are medical all of the time. But the enormous general problems raised by the high requirements from the patient of a prolonged time investment, faithful cooperation, and adequate solution of personal economics, with a high rate of recurrence as a reward for their combined solution leave one in a pessimistic state of mind. The failure of medical treatment lies in its insufficiency rather than its potentiality. To be successful such treatment must be rigorous and protracted. The loyal cooperation of the patient is essential. Very few patients now receive any treatment offering a reasonable prospect of healing of the ulcer. It has been observed that in most hospital groups the enthusiasm for all this resides with the younger clinicians, that older men as a rule exhibit less forcible advocacy.

From this state of affairs our surgical endeavors take origin. The satisfactions of resort to surgical measures in this instance are those common to surgery in general: the correction of diagnosis resulting so frequently from direct observation, the prompt elimination of pathology, the opportunity to eradicate associated pathology, notably appendicitis and cholecystitis in this instance, and a lowered incidence of return to the original problem.

It is my belief that these principles are best applied to the ulcer problem in the routine of what may be described as the average hospital by the conservative procedures which accomplish removal of lesion and modification of physiology, rather than by radical measures which consist in removal of the ulcer-bearing area.

Almost all duodenal ulcers that we are encountering lend themselves to the three chief surgical attacks, (1) the excision pyloroplasty after the method of Horsley, (2) the pylorotomy, usually best concluded by anastomosis between the end of the stomach and the side of the mobilized second portion of the duodenum, the Haberer-Finney gastroduodenostomy, or (3) by cautery excision plus gastrojejunostomy.

The first two procedures permit complete visualization of the problem, including the special factor of exposure of extra ulcers, plus removal of the pathology and a physiological correction of pyloric spasm; the last secures the same results in cases where location of lesion or degree of pyloric adhesions and stenosis predicate unsatisfactory handling of the pylorus.

Most gastric ulcers lend themselves to v-resection, or local cautery excision plus pyloroplasty or gastrojejunostomy, in the interests of reduction of recurrence. The more radical procedures of gastrectomy with removal of a large area of stomach plus various methods of gastrojejunal anastomosis have been practiced enthusiastically in certain compact well-standardized clinics but generally represent a lowered incidence of recurrence at the price of too high a mortality. The application of these operations to cancer or presumptive cancer is of course not in question.

The burden of surgery, while working under this program, must be frankly and accurately considered. The first and greatest problem is that of mortality. Herein it is my conviction, based on our own experience, that conservative procedures encounter a lower death rate than usually appreciated, a rate at least as low as that of medical treatment. Our 40 excision pyloroplasties for duodenal ulcer in the last four years, usually accompanied by appendectomy and twice by cholecystectomy, have been accomplished without a death. Our gastrojejunostomies have been a little less successful in mortality rate but



should not be used freely as a critical standard, because when properly applied they secure a high percentage of excellent results (90 per cent) in a group of cases representing advanced problems, of adhesions, stenosis and medical hopelessness. Here mortality rates are not the whole story, as may be well illustrated by reference to the fact that no one objects to a 50 per cent death rate in the surgical treatment of perforated ulcer out of respect to the gravity of the problem presented.

The greatest burden of mortality consists, as always in surgery, in the consciousness that death has followed an aggressive wilful procedure of one's own hand and decision.

The second important aspect of surgical treatment is the recurrence rate. Working without full appreciation of cause or prevention, we are not surprised at a definite rate of recurrence, especially in our younger cases. But the fact remains that observance of this event is overwhelmingly more common after non-surgical treatment. This may be related to the fact that surgery usually removes a probable cause, namely, an area which has undergone certain retrogressive circulatory changes. In any case, particular stress should be laid on the fact that the failure of surgical treatment in the form of recurrence is frequently not a weighty problem. In one of our excision pyloroplasties, symptoms persisted as a result of recurrence or operative overlooking of a second ulcer. Six months of medical regime made slight impression on the symptoms. Gastrojejunostomy, easily performed, then brought immediate and complete relief.

The third question raised by surgical treatment is that of complications. Of these, pneumonia, peritonitis and pulmonary embolism represent depressing problems but ones of rare occurrence and their discussion belongs to general surgical studies. Postoperative hemorrhage does not exist as far as we are concerned. Suturing these regions with the finest

chromic (000,000), Moynihan has not been betrayed by a single strand in over 2000 operations, and without crowding him very closely numerically our experience is the same.

Most significant of the complications is that of jejunal or gastrojejunal ulcer following any of the gastrojejunal anastomoses. The recognition and treatment of this condition are always difficult but usually satisfactory. Our 2 cases, of course, following the other fellow's gastrojejunostomies, have made perfect recoveries. But it should be emphasized that the occurrence is rare (about 2 per cent), and being definitely lowered by proper appreciation of probable factors in causation, namely, location of gastric opening, degree of operative trauma, type of suture material and detection of persistent postoperative high acidity.

Turning to the second issue, there is a specific point to make. It has been intimated that standardization of procedure in non-surgical treatment is in actual practice; it should be emphasized that standardization of surgical approach is still in the formative period. When one considers that the surgical application by Lister and others of Pasteur's principal contribution to medical science, occurred within the recollection of many here, that William H. Welch in a comprehensive review of the ulcer problem in 1885 devoted nine pages to medical treatment and but one paragraph to the surgical treatment of pyloric stenosis, that ulcer surgery was born largely in the nineties and was still in its infancy in the first decade of this century, that fifteen years ago in this hospital practically all the ulcer surgery was for perforation or advanced conditions with total disability, it becomes evident at once that the most important ingredient in the composition of a surgical formula, the time factor, has been allotted insufficient opportunity for development. Two of the three procedures herein described as conservative, the excision pyloroplasty of Horsley and the gastroduodenostomy of



Haberer and Finney have been originated in the last eight to nine years and are as yet not properly represented in most published series of results.

We are still in the stage surgically where frailty of human thought can produce both the unconvincing conservatism of a Lahey and the illogical radicalism of a Finsterer; but throughout there runs a definite evidence of progression, the lowering of mortality, the reduction of incidence of complications and more appropriate application of particular procedures. Operation with a fixed determination to do a certain kind of operation is being relegated.

One of the biggest factors in our control and progress is the enormous value of the roentgenological contribution, during every phase of ulcer management. It makes it harder for medical men to diet cases even unto death, and restrains surgeons from operating on everything in sight. It has done away to a great extent with the pseudo-criterion of cure, namely, the patient is comfortable.

This issue of standardization might well be left in terms of Valleix's conclusions on the ulcer subject expressed in his medical treatise of 1853:

Must I now present a summary and rules? I think not; for this would be choosing to give an air of precision to a subject which, in the actual state of science cannot be had. It is necessary that the physician know that which has been put to use, but he is not to believe, without an attentive and preliminary study, in order to consider the conditions which this case presents to him and the means to combat them.

Lastly arrives the third issue, the approach to the concrete message.

Medically we are at a standstill, an unsatisfactory standstill, with only the hope of some ultimate discovery leading to knowledge of cause and cure.

Surgically, we have under consideration a mobile state of affairs in which progress has been so rapid and so recent that there seems to be a lack of general appreciation of its victories. Most anti-surgical expressions quote old figures, or rely upon views of extremists that are strikingly omnipresent in all formative periods. Many such views are enthusiastically followed. Goethe said, "Some men make the last book they have read the master of them." One might paraphrase, that some who seek a solution for our complex ulcer problems, make last week's medical journal the sealed treasure house of their faith. In the words of Robinson's "Tristram":

Wisdom is not one word and then another,  
Till words are like dry leaves under a tree;  
Wisdom is like a dawn that comes up slowly  
Out of an unknown ocean.

To some, surgical approach of the ulcer problem is still in the scavenger stage, a clean-up business as a last resort. Actually the results of surgical approach are not satisfactory to any of us, but this dissatisfaction can not be disassociated from the evidences of progress.

"It is a dangerous man who believes everything he says," but analysis of this whole problem in its broader aspects, discloses, I believe, that the treatment of gastric and duodenal ulcer is making unsteady but definite progress with the surgical interests constantly increasing their share of the load.



# INTERNAL DRAINAGE

## A NEWER CONCEPTION OF THE CAUSE OF POSTOPERATIVE DEATH OF PATIENTS WITH PULMONARY ABSCESES, BRONCHIECTASIS, AND PULMONARY TUBERCULOSIS; SUGGESTIONS AS TO PREVENTION\*

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WHEN a patient, who is apparently a good operative risk, dies immediately after or within three days following a properly chosen and skillfully executed surgical procedure, one naturally speculates as to the cause of death. Previously these deaths had been ascribed to postoperative shock, cardiac failure, acute pulmonary edema, postoperative bronchopneumonia, extensive massive collapse of the lung, pulmonary or cerebral embolism, or toxicity from the anesthetic agent. In view of the difference of opinion as to the terminal diagnosis, it is important to determine on what basis each diagnosis was made, because it is possible that all of these terms may be used to designate a single condition, namely, internal drainage.<sup>1,2,3</sup>

By internal drainage we mean the spilling of pus or secretion from a diseased bronchus into the neighboring bronchi of either lung to obstruct the air flow and spread the disease. Internal drainage is a definite entity, and an understanding of its mechanism is important in the successful management of pulmonary conditions (Figs. 1-3). The areas to which secretions spill within the tracheobronchial tree are dependent on: the posture of the patient, the site of the primary lesion in the lung, the patency of the diseased bronchus, the amount and viscosity of the intrabronchial secretions, the anatomical position of the various bronchial openings, and the course of the bronchial stems (Fig. 4). The longer a patient remains in a given position, the greater will be the amount of spilling, provided that the diseased bronchus is open and the pus is of sufficient quantity

and not too viscid. Thick material does not flow readily but tends to plug a large bronchus and leads to an extensive pulmonary atelectasis; whereas the thinner material runs into the dependent minor bronchial openings (Fig. 5).

The first clue to internal drainage as the cause of certain postoperative deaths was afforded by a study of our autopsy records; since that time the condition has been recognized clinically and effective measures of prevention and treatment adopted. A critical analysis of these clinical signs and pathologic findings in 4 of our earlier cases will serve to illustrate the practical importance of internal drainage and the seriousness of overlooking it, as well as the favorable results which follow careful attention to it.

**CASE 1.** A patient with a pulmonary abscess at the right base was operated upon, a cauterized pneumonectomy being done, and her immediate postoperative convalescence was uneventful until the fourth day. At that time there was a slight amount of bleeding from the wound which seemed to have been controlled by packing. A few hours later, however, she developed a peculiar air hunger and died in a few minutes. We interpreted this as a pulmonary or cerebral embolus, but our diagnosis was not confirmed by pathologic examination. A large clot of blood was found occluding the main bronchus of the sound lung, thus producing a marked obstructive emphysema on this side. The patient died from strangulation as the occluded left bronchus prevented the normal function of the left lung and the diseased right lung was insufficient to maintain life.

Immediate bronchoscopic removal of the clot from the left main bronchus very probably would have been the means of saving this patient's life, but the clinical diagnosis was so

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misleading that adequate emergency treatment was not instituted. The clot spilled over by internal drainage from the lung operated upon



FIG. 1. Iodized oil introduced through the mouth without any type of anesthesia.

into the contralateral one while the patient was lying on her left side.

This case illustrates clearly the need for most careful hemostasis in connection with intrapulmonary surgery as well as the danger of collected intrabronchial material spilling into the opposite lung during changes in the posture of the patient.

The effects of this undesirable internal drainage were demonstrated in an equally dramatic manner in a patient with a bilateral bronchiectasis. (Fig. 6).

CASE 11. This patient was operated upon under scopolamine-morphine and local anesthesia. Large sections of several ribs were excised on the right side immediately overlying the diseased area, and a considerable portion of the lung was removed with the actual cautery. There was a moderate amount of bleeding during the cauterization. Cyanosis was marked and breathing was labored throughout the entire operation. The patient died when, at the end of the operation, he was turned on his sound side for the application of dressings.

Artificial respiration and stimulation had proven of no avail. Clinically a terminal diagnosis of operative shock was made, but the autopsy proved it to be incorrect. Pus and blood had spilled over by internal drainage from the area operated upon into the main bronchus of the left lung while this side was in a dependent position on the operating table. This intrabronchial material shut off the air flow and the patient died of asphyxia (Fig. 7).

If the problem of internal drainage had been appreciated at the time that we saw this patient, I am sure that more careful attention would have been given to hemostasis and the intrabronchial material would have been removed by bronchoscopic aspiration when the cyanosis and difficult breathing developed. If the bronchial passageways had been cleared and normal air flow maintained, this patient probably would have lived. It is hazardous to turn a patient on his sound side at the end of a chest operation if there is any question of the presence of excess material within the tracheobronchial tree, because such a posture will facilitate the spilling of this material into the previously uninvolved lung. This is particularly so when scopolamine anesthesia has been used. In such instances the narcosis persists so long after the completion of the operation that the patient is in no condition to cooperate in the evacuation of the collected intrabronchial secretions. Scopolamine is a poor anesthetic not because of its toxicity but because of this long period of narcosis with its attendant dangers. Nitrous oxide and oxygen anesthesia is much more desirable since the patient awakens very shortly after the operation is completed.

CASE 111. A patient with a right-sided basal pulmonary abscess of six months' duration, was expectorating 300 c.c. of pus daily, but he appeared to be a good surgical risk. Under scopolamine-morphine and local anesthesia, large sections of the ribs were removed, overlying the diseased area, and the lung was sutured to the parietal pleura but the abscess itself was not opened. On his return to the ward the patient was placed in the semi-Fowler position with the affected right side uppermost. He was still decidedly stuporous from the scopolamine and was experiencing exceptional difficulty in evacuating the pus from the bronchi. Cough was persistent and hacking but unproductive.

Breathing was shallow, rapid, and labored. The pulse was rapid and thready. Cyanosis and dyspnea had ensued and the temperature

operative bronchopneumonia or cardiac failure associated with an acute pulmonary edema, but this was not substantiated on post-mortem

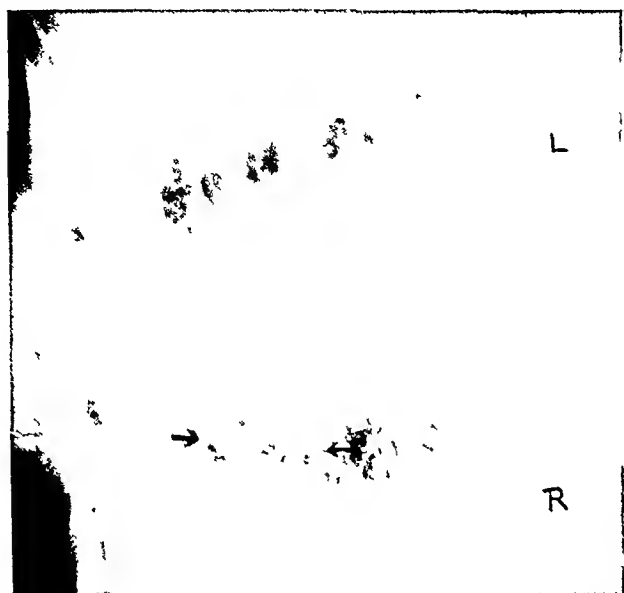


FIG. 2. Internal Drainage (Same patient as Fig. 1). Oil spilled from right lower into right upper lobe after patient had been lying flat on right side for a few minutes. There is no oil in left lung.



FIG. 3. Internal Drainage (Same patient as Figs. 1 and 2). Oil spilled from right lung into left when left side was dependent. No cough associated with this spilling. Migration of oil dependent on posture.

rose rapidly. Loud inspiratory and expiratory gurgling rhonchi could be heard when standing 2 ft. from the patient. There was a bilateral

examination. The patient really died of asphyxia. Pus had spilled from the abscess across the bifurcation of the trachea so as to



FIG. 4. Anatomical specimen illustrating relationship of various bronchial openings and facilities for spilling of secretion from one to other. T, trachea; L, left main bronchus; R, right main bronchus; C, carina (bifurcation of trachea); LU, left upper lobe bronchus; LL, left lower lobe bronchus; RU, right upper lobe bronchus; S, septum between right lower and middle lobe bronchi.

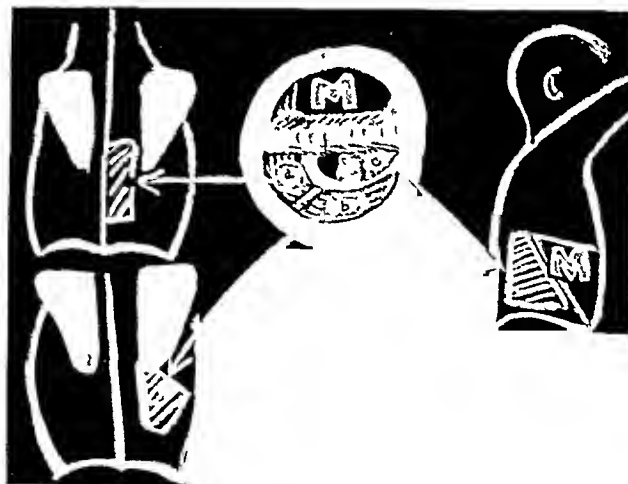


FIG. 5. Bronchoscopic appearance of middle and lower lobe bronchial openings and areas at which abnormal physical findings appear when minor bronchial openings of lower lobe are filled with secretion. M, middle lobe bronchus and area of chest wall at which its signs are heard. a, b, c, minor bronchial openings of lower lobe.

distribution of râles and rhonchi. The condition became progressively worse and the patient died on the third day after operation.

The terminal picture suggested a post-

occlude the left main bronchus and produced obstructive emphysema on this side. Probably the outcome would have been different

had we understood and applied the principles of internal drainage. It is now quite clear that there was a poor choice of anesthesia; posture

failure and acute pulmonary edema should be appreciated. Expectorants should be employed instead of atropine, and all measures tending to



FIG. 6. Bronchiectasis. Iodized oil injection of right tracheobronchial tree by Dr. June Harris. Note dilated bronchi at right base. Diaphragm is elevated and trachea ( $\tau$ ) is displaced towards right.

was faulty both on the operating table and on return to the ward; the bronchial passageways were not kept clear; and there was a failure to diagnose the true condition, thus preventing adequate treatment.

This patient should have had a bronchosopic aspiration before and after the chest operation. Nitrous oxide and oxygen should have been the anesthetic of choice. The Trendelenburg position should have been employed not only in the operating room but also after the patient's return to the ward. One must warn against the semi-Fowler position with the diseased side placed uppermost, as this facilitates involvement of the sound lung and permits the secretions to run so deeply into the smaller dependent bronchi that effective evacuation is almost impossible. These difficulties are increased when atropine is administered because the secretions then become so thick and viscid that expectoration is almost impossible. Consequently the seriousness of diagnosing these conditions as cardiac

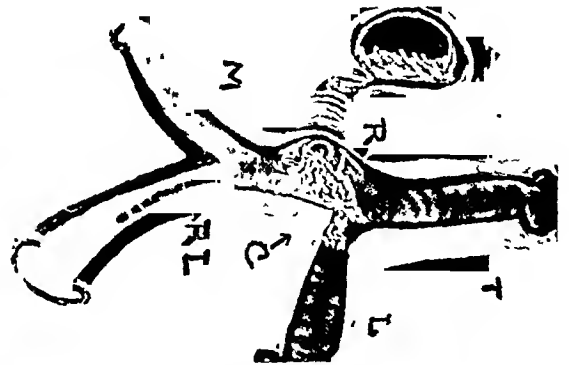


FIG. 7. Internal drainage: tracheobronchial tree showing pus spilling from right-sided abscess so as to occlude both main bronchi and shut off air flow. Pus flows into left lung when left side is dependent. T, trachea, R, right main bronchus, L, left main bronchus, C, (carina) bifurcation of trachea, A, pulmonary abscess, M, middle lobe bronchus, R L, right lower lobe bronchus.

aid in the evacuation of pus should be fostered. Among these are: strapping of the chest wall to lend support in coughing; morphine and codeine in sufficient quantities to control the pain, check the harassing, fatiguing, ineffective cough, and gain the cooperation of the patient. If carbon dioxide inhalations are used, the patient should be in the Trendelenburg position during the treatment. The semi-Fowler position is not desirable when using carbon dioxide unless the upper lobes are involved; but even in such instances, the erect posture should be followed immediately by the Trendelenburg position to evacuate the material that has spilled from the upper lobe bronchi into the more dependent ones. If adrenalin is administered preceding the postural exercises, the resultant widening of the bronchi will further facilitate the thorough evacuation of the intrabronchial pus.

CASE IV. Under the same type of anesthesia as that used in the previous cases, a large portion of a pulmonary neoplasm was excised with the actual cautery. On return to the ward the patient was placed in the semi-Fowler position with the sound lung dependent and the diseased side uppermost. He was expectorating small amounts of blood; shortness of breath and cyanosis were developing, and inspiratory and expiratory wheezes could be

heard throughout both lungs. In view of our experiences with the serious effects of undesirable drainage in the previous cases, we assumed that the alarming signs and symptoms were caused by the spilling of blood from the cauterized lung into the bronchi of the good lung so as to obstruct the air flow. When the faulty posture was corrected and the patient was placed flat in bed with the good side uppermost, the symptoms were soon relieved and the abnormal signs disappeared from the sound lung.

From a study of the previous cases, it becomes apparent that serious consequences are the result of failure to appreciate and apply the mechanical principles involved in the diagnosis and treatment of pulmonary diseases.

The problems herewith described are encountered also in the surgical treatment of pulmonary tuberculosis. A close attention to detail should not only lower the immediate postoperative mortality but should aid also in lessening the postoperative spread of the disease throughout the lung.

I believe that internal drainage explains not only the sudden deaths and postoperative pulmonary complications following operations upon the thorax but that it is responsible also for the onset of postoperative pulmonary atelectasis (massive collapse) following any type of operation. In the latter instance, secretions are aspirated from the mouth and nasopharynx and spill from place to place within the tracheobronchial tree depending on the posture of the patient. These secretions plug the bronchi, obstruct the air flow, lead to a localized bronchial infection and edema, and ultimately leave the patient with a postoperative pulmonary atelectasis

## CONCLUSIONS

1. Internal drainage is the spilling of intrabronchial secretions from the diseased bronchus into the neighboring bronchi of either lung. This results in a dissemination of the infection and an obstruction of the air flow.

2. Internal drainage is a causative factor in many of the deaths that occur following operations upon patients with pulmonary abscesses, bronchiectasis, pulmonary tumors, and pulmonary tuberculosis.

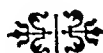
3. These deaths have been ascribed previously to postoperative cardiac failure, bronchopneumonia, cerebral or pulmonary emboli, operative shock, or scopolamine toxicity.

4. Postoperative pulmonary atelectasis (massive collapse) can be explained also on a basis of internal drainage. Aspirated pharyngeal secretions spill from place to place within the tracheobronchial tree depending on the posture of the patient, and result either in an obstructive emphysema or obstructive atelectasis.

5. These postoperative complications may be prevented if there is a careful choice of anesthetic, selection of proper posture, strict attention to hemostasis, and removal of excess intrabronchial secretions.

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# I. ARTERIOSCLEROTIC DISEASE OF THE EXTREMITIES\*

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IN arteriosclerosis of the vessels of the extremities with or without the association of diabetes mellitus the clinical picture depends upon the extent of impairment of circulation. Proliferative changes and deposition of calcareous material in the walls of the vessels result in a loss of elasticity and a diminution of the lumen of the affected vessels. These two factors give rise to definite clinical evidence of impaired circulation, which should be recognized in order that prophylactic measures may be instituted to delay or prevent the formation of bland or septic thrombi, which usually precipitate gangrene.

## CLINICAL FORMS

1. Intermittent claudication, which is not to be regarded as a disease per se, is frequently the only symptom present for many years. Pulsation in the dorsalis pedis or tibial arteries is however, likely to be absent.

2. Intermittent claudication may be accompanied by other evidences of impaired circulation, such as ischemia on elevation of the part, erythromelia on lowering the extremity and coldness and paresthesia. Vasomotor symptoms are not uncommonly present.

3. Without intermittent claudication and without the occurrence of trophic disorders, there may occur pallor of the foot when it is neither elevated nor dependent; erythromelia when it is dependent, coldness or cyanosis of the part, and absence of pulsations in dorsalis pedis and tibial arteries.

4. Forms as mentioned, because of exposure to cold or other insult, may be complicated by trophic disturbances or gangrene, either of which may become infected.

5. Pain of intermittent claudication may be so augmented by that accompanying chronic rubor that walking becomes too much of an ordeal. Edema may also be present for a long time in these cases without the occurrence of trophic disorders.

6. In cases with intermittent claudication or even with a combination of a number of symptoms, a developing collateral circulation may bring about improvement, or thrombosis may occur suddenly in the popliteal or femoral artery giving rise to the following complex. The patient will experience sudden pain in the calf or in the foot, and there will be marked pallor and coldness of the foot with loss of pulsation in the pedal vessels and not infrequently even in the popliteal or femoral vessels or both. After a variable time trophic disorders manifest themselves, and gangrene is likely to develop, especially if the thrombosis extends and measures to increase the collateral circulation are not instituted.

7. Cases presenting symptoms of faulty circulation are likely to show trophic changes such as impaired nail growth, fissures, atrophic skin, edema, callosities and ulcers. These are objects for the patient's attention, and he frequently infects himself while attempting to improve these conditions. Septic thrombosis is prone to occur especially in the presence of a hyperglycemia, and gangrene is frequently the inevitable end-result.

8. Buerger states that some patients, not necessarily senile, with extensive obliteration of the arteries of the lower extremities, may present a picture of chronic atrophy associated with slow development of gangrene that may persist for months or years without infection and without complicating moist gangrene. In these, venous occlusion is not present.

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## CLINICAL COURSE

Patients first notice that walking, especially in cold weather, causes pain in the calf or foot. They are likely to attribute this pain of claudication to rheumatism or strained muscles. This may persist for months or years before they notice that their toes or feet are cold and numb. Ulcers and other trophic changes, which may develop in time, occur less frequently than in thromboangiitis obliterans. Thrombosis may occur and unless collateral circulation becomes adequate, ulcers or patches of gangrene result, which may or may not clear spontaneously. As channels of collateral circulation are also involved in this disease, the remissions so characteristic of thromboangiitis obliterans are not so common. Although improvement may occur, coldness or erythromelia usually persists and finally exposure or some other insult produces dry or moist gangrene. If the patient has diabetes, he is not unlikely to develop without apparent cause, a perforating ulcer complicated by infection and bone necrosis. Even though trophic changes may never occur, examination will always reveal signs of deficient circulation. Pulsations are regularly absent, and elevation of the part elicits an increased pallor.

It is during these early stages of the disease that the patient should have the advantage of prophylactic measures.

Later patchy or massive gangrene may develop spontaneously from thrombosis or embolism, or the patient may wear tight shoes, trim a corn, expose himself to cold, or sustain a minor injury and thus precipitate gangrene. Although the first and fifth toes are most frequently affected, there is no part of the extremity which is immune. If the gangrenous area does not become infected, it may remain dry and the toe finally becomes a shriveled, black mass. As these changes occur, pain becomes more and more severe until it is at times almost unbearable. Without infection a line of demarcation forms; but if infection occurs, the lesion frequently spreads due

to the cutting off of the blood supply by the inflammatory reaction in previously normal tissue.

## ARTERIOSCLEROSIS AND DIABETES MELLITUS

Arterial changes are common in patients with diabetes mellitus since the diabetic lives and dies in the arteriosclerotic age zone. Of Joslin's 4592 cases of diabetes mellitus the disease developed in two-thirds of them after the thirty-ninth year. With the advent of insulin therapy, the duration of the disease has been prolonged from a previous average of four years until now the average age of death is well above fifty-five years. Thus, with this increased duration of life arteriosclerosis is being more frequently observed, and diabetics are becoming of increased interest to surgeons. Formerly, 61 per cent of fatalities were due to coma; but with the application of Banting's contribution, arteriosclerosis as a cause of death has risen to 47 per cent, and one-fourth of all deaths in diabetics is due to the development of gangrene.

INCIDENCE OF ARTERIOSCLEROSIS IN  
DIABETIC GANGRENE

Due to incomplete records and other missing links in the chain, statistical evidence does not prove that the occurrence of gangrene in a diabetic is always due to arteriosclerosis of the affected part.

Eliason and Wright in reviewing their 55 cases of gangrene in diabetics state that of the cases in which the condition of the arteries was recorded 66.6 per cent showed arteriosclerosis, and 100 per cent of all pathological and x-ray examinations showed it to be present.

Of 70 cases of diabetic gangrene reported by Lewis, 61.4 per cent were noted to have arteriosclerosis of the affected extremity. He states that accumulating evidence indicates that so-called diabetic gangrene is due to arteriosclerosis.

## AGE OF ONSET OF GANGRENE

Lewis found in his series that senile or arteriosclerotic gangrene occurred at an



average age of 66.2 years, whereas diabetic gangrene developed at 54.4 years.

Eliason and Wright in their 100 cases of gangrene found the arteriosclerotic type occurred at an average age of 64.93 years, whereas the diabetic type developed at 59.2 years. It is interesting to note that in females diabetic gangrene appeared 3.56 years earlier than in males and that in the arteriosclerotic type the females had an advantage of 4.66 years on the males.

Joslin considers the sixth and seventh decades of life, particularly the latter, as the dangerous period in the life of diabetics for development of gangrene and finds the advancing years of duration of diabetes, as well as the advancing years of life, likewise effective in the production of gangrene.

#### SEX

That arteriosclerosis occurs more frequently in men than it does in women is well known and this fact is borne out by the occurrence of arteriosclerotic gangrene in 36 males as compared with 9 females in Eliason's series.

Joslin has found that in Jews diabetes mellitus occurs more frequently in the female. However, it has been found considerably more frequently in the male by Osler, Fletcher, Stevens, and innumerable insurance company medical examiners. Diabetic gangrene in Joslin's series was twice as common in the male, and in Eliason's series of cases there were 33 males to 22 females.

#### PROGNOSIS

Gangrene in the diabetic has been mentioned as the cause of death in 25 per cent of all patients dying with diabetes mellitus. Eliason and Wright have determined that the duration of life in diabetic gangrene is seventy-two days as compared with 7.23 years in arteriosclerotic gangrene. Since in the former the onset is 5.73 years earlier and in the latter the duration of life is 7.03 years longer, the diabetic with gangrene is found to die 12.86

years sooner. These figures suggest a poor prognosis for the diabetic; but no doubt they are misleading because of the fact that they are based on many results obtained before the advent of insulin therapy.

#### PATHOLOGY

Arteriosclerosis according to Marchand is a deteriorative disease of the vessels. The term, denoting hardening of the vessel walls, originated with Lobstein. More recently it has been called atherosclerosis because of the fatty changes that occur, and Virchow suggested the still frequently used endarteritis in order to call attention to the hyperplastic lesion in the intima.

The pathology in arteriosclerosis of the extremities of the diabetic is the same as in the non-diabetic according to Buerger. However, McKittrick and Root believe that in diabetes mellitus there is a predominance of the intimal changes over those of the media as described by Mönckeberg. At any rate the changes are so nearly alike that they may be discussed together. In the diabetic the lesion is likely to be more marked and diffuse and because of the existing metabolic deficiencies gangrene is more prone to develop following trauma. An ulcer once present is likely to become infected, and septic thrombosis may result, further decreasing the blood supply and favoring the spread of phlegmonous inflammation and the development of gangrene.

In both types marked occlusion of the vessel may develop from a heaping up of calcareous material or a combination of this process and secondary thrombosis, or from a moderate degree of proliferative changes with an obturating thrombosis. Even with only moderate occlusion the loss of elasticity in the walls of the vessel results in impaired nutrition to the part. Not infrequently bone may be formed in the media and very rarely a calcareous plaque may break off, producing an embolic form of gangrene. Thrombosis is not unlikely to spread distally and proxi-

mally to involve the vessel from the foot up into the thigh. Although the veins and arteries both show changes, the characteristic lesion is confined to the arteries and is more marked in those supplying territories most subject to strain.

The earliest change is an overgrowth of the intima which is analogous to a normal physiological response. As this hyperplastic change progresses, it tends to undergo fatty degeneration and as a result there follows a proliferation of connective tissue which may be diffuse or circumscribed, depending on the extent of the degenerative foci. It is the accompanying fatty degeneration that makes this a characteristic arteriosclerotic lesion. In smaller arteries this process involves the intima uniformly, but in larger vessels it is more marked in certain crescentic areas that narrow the lumen and appear poorly supplied with capillaries but rich in hyaline connective tissue and secondary degenerative changes. This lesion is unlike the intimal changes in thromboangiitis obliterans which consist mainly of an increase of vascular elements. As this intimal lesion progresses there is a characteristic splitting or reduplication of the internal elastic laminae and a replacement of the fibrous tissue by calcareous material which may become abundant enough to form bone-like plaques.

Concomitant with the early changes in the intima, the media shows merely a reactive response which consists of cellular infiltration and the formation of new vascular channels. As occlusion of the lumen progresses these vascular channels in the media become more numerous and larger as if to compensate for the occluded lumen. These large channels or sinuses, when present, serve to differentiate arteriosclerosis from thromboangiitis obliterans in which vascularization does occur, but not in the form of large sinuses. After the reactionary stage there follows degeneration of the muscular fibers and separation of these by infiltrating fatty deposition. Simultaneously there is fibrous

tissue proliferation and a laying down of lime in streaks or plaques, and later bone formation may occur.

In the adventitia the paucity of lesions is pathognomonic for arteriosclerosis. There is no cellular infiltration, and the periarteritis of thromboangiitis obliterans is not present.

The larger arteries in arteriosclerosis are usually seen narrowed by the presence of a glossy gelatinous-like tissue of bluish pearly and yellowish appearance, arising from the wall of the vessel. This is either altered clot or proliferated intima with degenerative changes within it. If it is clot, it is seen on section to be organized. At first it contains newly formed vessels, but later it undergoes myxomatous and hyaline degeneration.

#### DIAGNOSIS

In an individual past fifty years of age with a history of intermittent claudication, loss of pulsation in pedal vessels, coldness and numbness of the extremity, occurrence of trophic disorders, blanching of the foot on elevation, and the occasional finding of rubor when the foot is pendent, one immediately recognizes that there is a circulatory disturbance which is most probably arteriosclerotic. Roentgenograms of the affected extremity indicate the extent of calcification present, but as thromboangiitis obliterans may have arteriosclerosis associated with it, differential diagnostic points must be sought. If a hyperglycemia is discovered, there is strong evidence that symptoms are due to arteriosclerosis.

In thromboangiitis obliterans the age of onset is usually between twenty and forty-five years, and the patient is, with very rare exceptions, a male. The development of gangrene is usually preceded by prodromal symptoms and signs for weeks, months, or years, and some of these are almost characteristic. Ischemia and erythromelia and trophic changes are more constantly present and more marked than is usual in arteriosclerosis. Migrating phlebitis is

typical and occurs in 25 per cent of cases. Gangrene, once it develops, is more apt to be dry and spreads less rapidly, due to the likelihood of an adequate collateral circulation becoming established. It not infrequently attacks the upper extremities, which almost never become gangrenous in arteriosclerosis.

With gangrene once developed it becomes important to determine whether or not the patient has diabetes mellitus and if the process has been precipitated by faulty circulation or infection plus circulatory deficiency. If the foot is cold, blanched on elevation, and dusky or cyanotic when dependent, it becomes evident that local circulation is deficient. Roentgenograms of calcified vessels and the finding of absent peripheral pulsations are in part confirmatory but they give no indication of the extent of collateral circulation present. The temperature and color of the part as elicited by the various well known tests are of great value as they are an index of the degree of collateral circulation present. Absence of pulsation in the popliteal artery gives no information concerning branches arising from the femoral artery just above the popliteal space. It is these branches which supply the upper third of the leg and even down to the ankle or base of the toes when collateral circulation is well developed.

When gangrene is due to infection or septic thrombosis it is usually quite evident. A history is obtained of a break in the skin which subsequently became infected, and the gangrene is of the moist variety. The dorsalis pedis pulse is usually palpable or if it is not, the foot is warm and of fairly good color, evidencing that collateral circulation is well developed. The process is superficial and localized, further indicating a fair circulation. This type of gangrene is more frequently seen in the diabetic patient.

#### TREATMENT

Prophylactic measures to prevent complications in arteriosclerosis are essentially

the same in the diabetic gangrene as in the non-diabetic. The patient is warned of the dangers of excessive walking, exposure to cold, the wearing of ill-fitting shoes or darned socks, the excessive use of alcohol and tobacco, and is especially instructed not to cut or trim ingrowing nails, corns, calluses, and bunions. In addition, the diabetic should be under the supervision of a cooperating internist whose objective should be to arrest the progress of arteriosclerosis. Joslin believes that an attempt should be made to make diabetics tolerate 100 gm. of carbohydrate daily so that fats may be more completely oxidized and thus lessen the progress of the arterial disease.

In patients having impending gangrene or in those not so threatened, but willing to cooperate, an attempt should be made to improve circulation. This may be obtained by the institution of Buerger's postural exercises, hot sitz baths, contrast baths, diathermy, heat tents, and the administration of typhoid vaccine.

Trophic disorders should be promptly and energetically treated to obtain healing and prevent occurrence of infection. Rest of the part is essential, and it should not necessarily be in the horizontal position. Close observation will frequently reveal that a more nearly normal color appears with a certain degree of dependency. It has seemed best to Buerger to maintain this optimum position. Dressings kept moist with hot hypertonic salt solutions are of most value in combating infection. In the diabetic the blood sugar must be more carefully controlled, as hyperglycemia is common when infections are present.

With the occurrence of gangrene in the non-diabetic, the nature and extent of the lesion determine the treatment. With dry gangrene of one or more toes showing a tendency to demarcate, conservative means should be given a trial. Dry heat is administered and postural exercises practiced. When demarcation is established below the plantar arch, the necrotic

parts should be pulled away to facilitate healing by granulation. Local anesthesia should never be used for obvious reasons. Should the gangrenous process continue to spread, amputation through the thigh is immediately indicated. In rare instances collateral circulation in the upper third of the leg may be adequate enough to warrant a trial below the knee. If bleeding does not occur at this level, a higher one above the knee should be selected. A circular amputation with skin closed loosely without a drain gives most satisfactory results. Eliason and Wright prefer high amputations for the following sound reasons: Healing occurs more quickly and shortens the stay in bed, thereby lessening the occurrence of complications in these senile patients. Shock is greater in high amputations but reamputation later carries an added mortality of 30 per cent. Stumps for artificial limbs should not be considered as elderly individuals will not attempt to use anything but crutches.

Should gangrene be precipitated by infection, conservative measures will suffice if localization occurs. However, if the gangrene is due to circulatory deficiency and becomes subsequently infected, the picture is a different one. Dry heat and exercises are contraindicated as they facilitate extension of the process. Immobilization with the part elevated is indicated as are means to induce drainage and combat infection. In this type lymphangitis, edema, and signs and symptoms of systemic intoxication are to be expected. With occurrence of these, high amputation is indicated.

Numerous radical measures to increase collateral circulation have been suggested. Some have proved worthless and others have not been sufficiently used to warrant the drawing of any definite conclusions. In pregangrenous states certainly anything is worth trying, but once gangrene has developed temporizing procedures may endanger life.

To lessen coagulability of blood in certain vascular disorders various salt solu-

tions have been used by Clardidge, Main, Meyer, Stone, Koyana, Steel, McArthur, Evans, Maes, and Boving. Although thrombosis occurs in arteriosclerosis and it may seem desirable to lessen the process, it must be pointed out that any procedure necessitating multiple venipunctures is not unattended with danger in the arteriosclerotic patient.

Surgery of the sympathetic system can hardly be expected to produce vasodilatation in non-elastic arteries and is therefore of no value.

Bernheim has performed a periarterial sympathectomy in 8 cases and reports it as a "tiding over process." He claims that it relieves pain, dilates any vessels that can be dilated, and thus serves to tide the patient over his stress. He believes that it is a simple, harmless procedure worth trying in selected cases of patients whose blood pressure is high enough to develop collateral channels. That this procedure has ever produced more than a temporary vasodilatation is to be doubted but it does relieve pain in some cases.

Arteriovenous anastomosis between femoral artery and vein has been demonstrated experimentally to be of no value by Horsley and Whitehead. They found that reversal of circulation takes place for only a short distance.

Because of the extensive collateral circulation developed in thromboangiitis obliterans, Lewis and Reichert advocated ligation of the femoral artery below the origin of the profunda, believing that the increased systolic pressure obtained proximally for a variable time serves to open up collateral channels. Certainly such a procedure could only be of value when the artery is not already occluded.

In 1913, Oppel ligated the femoral vein in 6 cases and obtained favorable results. Later Pearse proved experimentally that simultaneous ligation of the artery and vein resulted in improved function and less gangrene than after ligation of the artery alone. Since in arteriosclerosis the artery is frequently occluded, Morton and

Pearse decided to ligate the popliteal vein in suitable cases. Later they reported that in the 9 cases so treated the patients were relieved of their pain at once and experienced a feeling of warmth in their feet. Their results were entirely gratifying except in those cases in which pulsation was absent in the popliteal artery. In these they believe a femoral vein ligation should be done. This procedure seems to offer possibilities in selected cases. In cases without marked arterial occlusion the artery and vein should be ligated at the same time.

In the diabetic the lesions might well be classed as those due to deficient circulation and those precipitated by infection. McKittrick and Root, of Boston, use this classification in their book on "Diabetic Surgery." The reader is referred to this excellent work for greater detail in the treatment of gangrene and infections in the diabetic.

In cases with deficient circulation conservative measures aim to combat infection, remove gangrenous sloughs and stimulate circulation and healing. This should be attempted in the following types of cases:

1. Superficial ulceration or gangrenous patch below the middle third of the leg when the dorsalis pedis pulsation is palpable.

2. Superficial lesions with slight infection in the absence of pulsation of dorsalis pedis but with good collateral circulation as evidenced by warmth and color that compares favorably with the unaffected foot.

3. When healing by first intention has failed in the absence of infection following any operative procedure on the lower extremity.

Infection is best treated with immobilization and frequently changed dressings, moistened with hot hypertonic salt solution.

Sloughs should not be excised as the bases and edges nearly always become dry and form a new and larger slough. Moist dressings should be maintained until the margins of the slough separate so that it may be removed by gentle traction.

Means to increase circulation in the presence of mild infection should be judiciously employed. Dry heat is undesirable, but hot baths are of value when it is known that burns will not be permitted to occur in the presence of a hypoesthesia. Cluzet and Chevallier, in France, have reported excellent results from the use of diathermy. Buerger's exercises are of distinct value, and limited active exercise is beneficial in selected cases. Injections of typhoid vaccine, though not yet used extensively, should prove of value.

McKittrick and Root report excellent healing and growth of epithelium with the use of flamed strips of adhesive plaster over healthy granulating areas.

Operative treatment becomes necessary when gangrene occurs in one or more toes, when pain persists, when infection endangers life because of the patient's poor general condition and when economic conditions demand it.

Incision and drainage of a gangrenous toe are never indicated; but with a pulsating dorsalis pedis or evidence of good collateral circulation in the foot, amputation of the digit should give a satisfactory result and may even clear up an infection slightly proximal to it.

Operative procedures as advocated to increase circulation in thromboangiitis obliterans, arteriosclerosis, and other vascular disorders have not been given sufficient trial in the diabetic to warrant discussion; McKittrick and Root feel that the delay attending these abortive procedures jeopardizes the life of diabetic patients with gangrene or impending gangrene.

Eliason and Wright advocate immediate and high amputations through the thigh when gangrene occurs. In their series they show that re-amputations carry an added mortality of 30 per cent and that 50 per cent of their deaths in re-amputated cases occurred in those patients who had been subjected to useless and temporizing operations.

Major amputations become definitely

indicated in cases presenting (1) gangrene of one or more toes with absence of dorsalis pedis pulse and an inadequate collateral circulation in the foot or when there is a distinct point of temperature change in the lower leg even though the foot is fairly warm; (2) gangrene with infection spreading to deeper structures of the foot; (3) evidence of deficient circulation without gangrene but with pain unrelieved by conservative methods; (4) a viable foot but with infection endangering life.

McKittrick and Root in adhering to these rules as outlined had only 6 re-amputations in 61 cases, proving that conservatism is warranted when the state of circulation is determined and fully appreciated.

Although most surgeons still amputate through the thigh in all cases of diabetic gangrene, it has been shown by Maes and others that lower levels may be selected in certain cases. Because amputation below the knee carries a lower operative

mortality and favors function, it has been used extensively with success by McKittrick and Root in presenile cases without rapidly spreading infection if (a) the skin is warm and of good color to the level of the ankle; (b) there is good pulsation in the popliteal artery; (c) there is no evidence of lymphangitis or phlebitis above the lower third of the leg. These workers use either a circular incision or short lateral flaps in the leg and the Gritti-Stokes amputation for the thigh. More uniform results may be expected from the routine use of circular amputation in all cases.

In the diabetic trauma is likely to precipitate infection in spite of a comparatively good blood supply. Early energetic conservative treatment usually suffices but major amputations are indicated in a patient with (a) general septicemia resulting from an infected foot; (b) local infection too extensive to drain adequately; (c) sepsis of a foot which is endangering life.

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## VASCULAR DISEASES OF THE EXTREMITIES

### II. ERYTHROMELALGIA \*

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IN 1872 Weir Mitchell<sup>1</sup> described a vascular disorder of the extremities which he appropriately termed "erythromelalgia" to signify the occurrence of pain and redness in an extremity. Though Paget<sup>2</sup> and Graves<sup>3</sup> had previously described cases in which these phenomena occurred, it remained for Mitchell to show that these symptoms always came on when the extremities were dependent and that they were aggravated by heat, relieved by cold or rest, and represented a disease entity different from the one described by Raynaud.

#### ETIOLOGY

The cause of erythromelalgia is unknown. Certain cases, observed sufficiently long to rule out vascular obstruction, strongly suggest that the symptoms are due to a sympathetic nervous system lesion, whereas in a few the existence of a peripheral nerve lesion seems a probability.

#### INCIDENCE

The disease is rare<sup>4</sup> there being only 15 cases of erythromelalgia among 400,000 admissions to Bellevue Hospital in ten years. Cassirer<sup>5</sup> collected reports of 90 cases, but is doubtful whether all of these were erythromelalgia.

#### SEX

Lewin and Benda<sup>6</sup> found 29 out of 41 cases occurred in males; Cassirer, however, reported 32 women to 46 men affected.

#### AGE

Cassirer found 2 cases for each of the first two decades of life, 21 for the third, and approximately 11 for each later decade up to 60 years of age.

#### SITES OF LESIONS

In Cassirer's cases the pain and redness were localized in both feet in 24, one foot in 9, both hands in 13, one hand in 4, and in all four extremities in 17.

#### CLINICAL COURSE

The onset is sudden, usually occurring during exposure or prolonged exertion on foot. The course is usually progressive, though at times it is remittent. At first a burning pain occurs in the ball of the foot, in the great toe or in the heel, whence it may extend over the sole of the foot and often extends over the dorsum of the foot to invade the lower portion of the leg. Elevation of the part affords early relief and the patient is not greatly disturbed for a time, but soon the pain becomes more severe and occurs during short periods of standing. The manifestations may become stationary, occurring daily, or intermittently, but more frequently there is progression. Merely hanging the feet down causes the pain, heat aggravates it and relief is obtained only after rest and local applications of cold. In this late stage of the disease, the pain is of a throbbing nature and is now accompanied by the characteristic erythromelia or rubor and increased surface temperature. The painful areas are marked by a dull, dusky, mottled redness, as if the smaller vessels were over-distended. With prolonged standing the veins become prominent, the arterial pulse becomes bounding, and the part gets redder and redder in color until at length it gives way to a purplish hue. In the more advanced and severe cases the part is cold and perhaps pale when elevated. Ultimately, when the part is dependent, the redness is no longer accompanied

\* Presented before the Surgical Faculty, Tulane University, April 21, 1930.



by increased heat, and it more quickly gives way to cyanosis. Transitory swelling frequently occurs and occasionally the part pits upon pressure.

#### SYMPTOMS

In addition to the occurrence of pain and redness on dependency of the affected part or parts, there are frequently other associated symptoms.

Hyperesthesia, even at rest, is fairly constant. The patient can not bear the touch of bed clothes and rarely can be made to wear stockings or shoes.

Hyperhidrosis over the affected areas is not uncommon.

About one-fourth of the cases manifest trophic lesions such as blebs, atrophy of the skin, thickening of the skin possibly due to connective tissue proliferation, dystrophies of the nails and hair, and, rarely, in the late stages, gangrene is a possible concomitant.

Muscular atrophy with an almost total loss of functional activity of the hands was reported in one case by Weir Mitchell.<sup>1</sup> However, Buerger states that local motor disorders such as paralysis, atrophy and reactions of degeneration in the distribution of one or more nerves, are absent.<sup>7</sup>

#### OTHER COEXISTING DISEASES

Both functional and organic diseases of the nervous system frequently coexist. Cerebral hemiplegia, paresis, tabes dorsalis, myelitis, and multiple sclerosis have been known to occur with erythromelalgia. Frequently a neuropathic habitus is associated, and psychoneurotic states are not uncommon.

#### PATHOLOGY

Of the pathology we know nothing. Cassirer<sup>5</sup> ventures to say it is very probable that the cases with local distribution of symptoms are due to changes in the peripheral nerves, while those with a wider distribution of symptoms are more likely due to a vasomotor disorder.

#### DIAGNOSIS

The diagnosis depends upon the manifestations of increased heat, pain, and redness when the affected part is dependent, and the disappearance of these on elevation. In the advanced case the differential diagnosis is easy, but, in the early stages, obliterative vascular disease and Raynaud's disease may be confused with it.

In Raynaud's disease, the patient is usually a female, the attack may be precipitated by cold, it begins with ischemia, and it may be relieved by warmth, while in erythromelalgia, heat precipitates an attack and cold relieves it. In the latter, the absence of gangrene, asymmetry, and increased heat in the affected part are important differential points.

Thromboangiitis obliterans when the pulses are absent is readily differentiated, but early, when only the terminal vessels are obliterated the differential diagnosis is extremely difficult. In erythromelalgia, color displaced by pressure is rapidly replaced, whereas in thromboangiitis obliterans it returns very slowly. Trophic lesions and intermittent claudication, if present, in the latter conditions serve as differential diagnostic points. The occurrence of ischemia on elevation of the part is important.

In arteriosclerosis there may be rubor and pain with the parts dependent; but the absence of pulses and other evidences of the disease serves to differentiate it from erythromelalgia.

#### PROGNOSIS

The prognosis is poor as to cure though the condition may be alleviated by prolonged rest. Gangrene is extremely rare.

#### TREATMENT

In those cases with local distribution of symptoms, excision or injections of the nerve at fault gives relief; but when there is a wide distribution, alleviation of the condition can only be brought about by prolonged bed rest, massage, electrotherapy, and analgesics. Contrast baths



and Buerger's exercises may be of value if they can be tolerated.

Moleen<sup>8</sup> reported that suprarenal substance benefited one of his cases.

Mayesima<sup>9</sup> reported a favorable result obtained by section of posterior nerve roots as suggested by Foerster.<sup>10</sup>

Leriche<sup>10</sup> states that nothing can be expected from sympathectomy. Davis and Kanavel<sup>11</sup> report the only case benefited by such a procedure. Their diagnosis in this case appears to have been established on the fact that the dorsalis pedis and posterior tibial pulsations were readily palpable. That these vessels may pulsate when thromboangiitis obliterans involves only the peripheral smaller vessels is well known. In view of this and the fact that their patient, a Russian Jew, manifested rubor with coldness instead of increased temperature in the toes and dorsum of

the foot only, one is justified, possibly, in considering this a case of thromboangiitis obliterans with vasospastic symptoms until further observation definitely establishes the diagnosis.

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\* Continued from p. 39.

# COMPRESSION FRACTURE OF THE SPINE

## WITH A REPORT OF 49 CASES AT FORDHAM HOSPITAL\*

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**F**RACTURES are on the increase along with modern industrial accidents. Spinal fractures, which are among the most serious, also show an increase. Even when the condition is recognized early, it is a serious problem and difficult to treat. If rational treatment is not provided, early disability is common. In some unrecognized cases, disability may begin late and progress gradually.

A great deal of the confusion in treatment is due to the lack of statistics. Many patients die before careful examinations can be made, while others require treatments for so long a time that they tend to wander and no one physician can follow the case to a complete cure. Most of the fractures occur in industrial work, and in automobile and train accidents, and the final results are complicated through the process of litigation. Studying statistics is interesting and valuable, but it is particularly important to study end-results.

As a member of the staff at Fordham Hospital, I found my interest in these cases aroused through the considerable number of spine fractures that I encountered. Fordham's location, in a section of dense automobile traffic, was a factor in this. In 1925 I<sup>1</sup> reported 61 cases, the number treated there from 1915 to 1925 inclusive. Since that time up to the end of 1929, we had 47 additional cases, making a total of 108. Of these, 49 were of compression-fracture type constituting 45 per cent of the total. These cases will constitute the report on which this paper is based. For the reader understanding of the subject, a brief review of the symptoms and treatments is perhaps advisable.

Osgood<sup>3</sup> asserts it frequently happens that compression fractures are not recognized early; diagnosis is faulty; they are

often treated by unsound methods and serious disability ensues; the medico-legal aspect is important. We know how to treat them and in uncomplicated cases, if we apply this knowledge, a return to full wage-earning ability may be confidently expected. This knowledge is not being generally applied.

### ETIOLOGY

Compression fractures may be caused by either direct or indirect violence. In nearly all typical cases, the mechanism of direct trauma is forced hyperflexion or jack-knifing of the spine. In addition to trauma in the longitudinal axis as occasioned by a fall on the head, the feet, or the buttocks, compression fractures of single vertebrae may be caused by a sudden uncoordinated demand on the muscles of the back as in a sudden turning of the trunk or by a false step. Examples of indirect forces are: violent contractures of the extensor muscles of the back which have led to spine fractures of the fourth and fifth lumbar vertebrae. "It is worth while remembering, that a definite and potentially disabling compression fracture may be caused by surprisingly simple and seemingly slight accidents" (Osgood).<sup>5</sup>

"The importance of a fracture of a vertebra depends not so much upon the fracture itself as upon the degree of dislocation of bone or bony fragments and the amount of injury to the spinal cord and nerve roots" (Elsberg).<sup>2</sup>

The fractures are situated most frequently in the lumbodorsal and the upper lumbar region. Athletes and men whose occupations are such as to render them liable to severe injury, as laborers and truck drivers, are the most frequent patients (see Table iv).

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## INCIDENCE

The percentage of compression fractures was 45, (Table 1), thus agreeing with Osgood<sup>5</sup> who claims that somewhat more than 40 per cent of all fractures of the spine are compression fractures.

## EXAMINATION OF AN INJURY TO THE SPINE

Scudder<sup>7</sup> suggests, as an aid in the examination of the spine, finding the answers to the following 4 questions: What was the nature of the accident? What does palpation of the spine reveal as to the nature of the lesion? What is the level of the lesion? Is the lesion partial or complete?

## SYMPTOMS AND SIGNS

Osgood's<sup>5</sup> warning is pertinent:

Two things must constantly be borne in mind: First, early typical symptoms and signs of compression fracture of the spine may be masked by the general shock of the accident and the frequent more painful associated bruises or fractures. Second, even in the absence of such masking complications, the symptoms of these potentially serious lesions may be so slight as to warrant only suspicion of a compression fracture. In all cases of possible injury to the spine, if this warrant is conscientiously served, future disability will be arrested.

A. *Pain*.—Increased by pressing down on the head and shoulders in the long axis of the column.

B. *Limitation of Motion* in all directions is the most constant sign. In the sprain of the back, the motion is limited in certain directions only. Pain may be absent, but limitation of motion is always present.

C. *Tenderness* over the spinous process is almost constant.

D. *Persistent Weakness* of the back occurs in all cases. Patient is unable to do anything, even the mildest type of work.

E. *Deformity*: Angulation kyphosis is usually present at the level of the lesion. The projection of the spinous process produces the kyphosis. In early cases, the kyphosis may be lacking.

F. *Involvement of the Cord*: In a consider-

able percentage of cases of spinal fractures, the cord is involved. The absence of cord symptoms does not however exclude fracture of spine. "If the cord has been only slightly injured the symptoms due to loss of motor and sensory power may be only slightly marked; but, if the cord has been crushed in its complete transverse diameter, there is at once a loss of all motor power, of all sensation, of the reflexes below the level of the lesion and with it a loss of the functions of the bladder and bowels" (Elsberg<sup>2</sup>). After a trauma to the vertebrae, the x-ray examination may be entirely negative, and yet the patient may have a most serious cord lesion. Some patients may show at first the signs of a partial lesion of the cord, but after a few days, due to a secondary softening, they develop the symptoms and signs of a complete transverse cord lesion. On the other hand, it is not at all unusual for the x-ray to show a very marked fracture and dislocation of bone in an individual who has few or no signs or symptoms of injury to the spinal cord or nerve roots.

G. *Kümmell's Disease or Posttraumatic Kyphosis*: In some cases, after a period of improvement, there develop pain and weakness of the spine followed by neurologic and motor disturbances of the legs. There may be a kyphosis. If untreated, these symptoms increase. These phenomena are believed to be due to a rarefying osteitis.

## COMPLICATIONS

The complications usually encountered are neurologic symptoms (where the cord is involved), fractures of the laminae, fractures of the transverse or spinous processes or fractures of the bones below the knee. Where one vertebral body is involved, the complications are rather rare.

Fractures of the transverse and spinous process seem to be comparatively unimportant lesions. The only difficulty is that these frequently occur in industrial accidents and legal entanglement complicates the proper result.

## ROENTGENOGRAPH IN INJURIES OF THE SPINE

A moderate degree of compression of the superior surface of the body will not be recognized in the anteroposterior view. The lateral view is the most satisfactory one for determining the size, shape and to a great extent the internal structure of the various bodies, as well as for showing the intervertebral spaces. The anteroposterior view often leads one to believe that there is decided narrowing, even occasional obliteration, of the intervertebral spaces in this region. Yet when the case is examined from the lateral view one finds the narrowing of the spaces to be only apparent and not actual. This view is the only one by means of which one may obtain an accurate idea of laminae and spinous processes. A negative opinion as to roentgen findings might be unjust to the patient by not indicating the proper treatments.

Increased density of actual breaking along the superior margin, usually anterior, of the vertebral body under question may frequently be shown, even in cases of very slight fracture. Frequently, there is apparent lifting of the dense cortical bone along the vertebral edge plus increased density, suggesting impaction of the bone trabeculae of this portion of the body. Late examination will show a certain amount of callus or new bone deposited along the area of the compressed bone which is easily visible. In most of these cases, lipping of the anterior margin of the body, similar to hypertrophic changes is found about three months after the injury. Persons over forty-five years of age will show more rapid development of hypertrophic changes or spur formation than younger individuals.

When the condition is not realized and the case continues to be ambulatory over a period of three or six weeks or longer, the changes found are rather characteristic; there are signs of atrophy of the body, the marginal edges are less sharply defined, as is also the fracture line. About the site of the fracture, there may be soft part involvement and organized hemorrhage to a certain extent. It is this sort of case that may cause hypertrophic changes, spur formation and evidence of nature's effort to anchor this body to the one above or below.

If immobilization of a fracture is attempted, films made at the end of the fifth week of treatment and at later intervals will show rearrangement of the sharpness of bone outline

and the disappearance of the indefinite increase of density about the body. Eventually the body assumes normal appearance except for the deformity due to the fracture, and for a certain period of time at least hypertrophic changes or spur formation as in the untreated case will not take place.

If the case continues to be unrecognized and untreated, the fractured vertebra becomes more or less wedge-shaped. This increases the amount of hypertrophic change and causes ankylosis of the injured body to the one above or below it (George and Leonard<sup>3</sup>).

## DIAGNOSIS

There are a great many cases of injury of the spine, even compression fracture, where there is absence of localized, general or referred symptoms. It is therefore of great importance to emphasize that each injured spine should be examined very carefully and neurological tests included. Frequent reexamination should be made. Roentgenographs should, of course, be made and carefully studied.

Diagnosis of fracture of the spine should be made on (1) the history of the injury, (2) localized tenderness, (3) localized and persistent pain in the spine, (4) referred pain from nerve roots in the region of the injury, (5) weakness and deformity of the spine, (6) cord pressure symptoms, as abnormal reflexes.

In several of the cases reported the diagnosis was missed on account of mildness of symptoms (see Cases II and V).

In differential diagnosis, especially in the late cases, one has to consider tuberculosis of the spine, malignant disease, degenerative hypertrophic arthritis and the recently described condition "osteochondritis deformans juvenilis."

Tuberculosis presents a very difficult task for differentiation. George and Leonard<sup>3</sup> give a good clue for the differentiation. "In the compression type of fracture there will be practically no change in the width of the intervertebral space, or at most very little, but the first manifestation of tuberculosis in the roentgen examination will be an appreciable narrowing of the intervertebral space."

## PROGNOSIS

The prognosis depends upon the amount of injury to the spinal cord. It is less grave than it was thought to be a few years ago. In general, the nearer the fracture approaches the medulla oblongata and the foramen magnum, the more serious is the outcome. Death is due in cervical fracture to shock and pressure upon the medulla. In upper dorsal fractures patients ordinarily die in a few days or weeks from hypostatic pneumonia. In fractures of the dorsal and lumbar regions patients die from cystitis, pyelitis and exhaustion.

Prognosis in these cases is a matter of the care given, more than it is of the extent of lesion. Recognized in time, properly supported, these cases do remarkably well after six months or a year. If they are neglected, the patient may become and remain a cripple.

Elsberg<sup>2</sup> gives a very definite suggestion for determining whether or not the injury has affected the entire thickness of the cord. The patient, with the signs of a complete transverse lesion—to wit—the loss of all power, loss of all sensation, loss of reflexes, loss of control of the bladder and bowels, will have one purely spinal reflex left. He should be examined every day, the examination including scratching of the sole of either foot. If this elicits a plantar flexion of the large toe for more than about two weeks (with the persistent loss of everything else) the injury to the cord is almost certainly irremediable. If on the other hand, the scratching causes a dorsal flexion of the large toe, the so-called Babinski sign, one may conclude that the patient did not actually have a complete transverse lesion.

In the average case of fracture of the spine with no nerve symptoms, the prognosis for ultimate recovery is good. The patient is soon able to walk, although this may be only with difficulty and caution. Some symptoms, however, may persist for a considerable length of time, especially pain and rigidity. The healing of fractured vertebrae is a slow procedure since the callus thrown out by the affected vertebrae,

as a rule, is comparatively small and forms very insidiously. Reckoning from the time of injury, the period of disability is from one to two years. In most cases a certain impairment and weakness of the back however, remains permanent so that the patient cannot resume any labor which requires a great deal of strain or stress (Steindler<sup>8</sup>).

## TREATMENT

*Immediate:* Relief of shock is important. After an injury to the back that prevents a man from rising, he should be placed on a flat stretcher. (The position assumed after the injury should be maintained, if it does not endanger life, until the surgeon sees the case.) At Fordham Hospital we are accustomed to putting the patient on a Bradford frame immediately. After examination, the patient should be catheterized. Accurate knowledge of the function of the kidneys will then be obtained during the first twenty-four hours.

*Direct Treatment of Cases without Paralysis:* Forceful correction (especially in dislocation or fracture-dislocation) or open operation should be undertaken only as a last resort. Treating the bone lesion is the first essential. Immobilization of the spine with particular attention to the prevention of the increase of the kyphosis, is to be done immediately. This can be carried out by fixation in the extended position. The Bradford frame, which allows the patient to lie flat on the back with hips and shoulders strapped down, answers the purpose. Opposite the kyphosis, on either side of the spinous processes, pads of felt are applied as a corrective measure. Day by day the padding can be raised without discomfort until the desired correction is reached. A Rogers frame is very useful in reduction of the fracture (Rogers<sup>6</sup>).

Occurrence of extreme abdominal pain may be a sign of nerve root pressure and is an indication for hyperextension irrespective of apparent deformity, for hyperextension relieves nerve root pressure by opening up the foramen.

After a few days, when the patient is out of shock, a better immobilization can

be obtained by a complete plaster-of-Paris jacket. Osgood and his school at Boston advocate a double plaster shell extending from well above the lesion, over the buttocks, to just above the knees. It must be well padded over bony prominences but closely and smoothly fitted. The patient can lie on this shell on the Bradford frame.

Careful attention must be paid to prevention of bed sores, the care of the bladder and bowels. If the patient is incontinent, the greatest care should be taken that the skin around the buttocks and genital regions does not become irritated from the moisture or soiling of the bedclothes. If there is retention, the bladder should be emptied at regular intervals by catheter.

The patient remains in complete recumbency for eight or ten weeks. He is then allowed to try sitting up in a well-fitting jacket or brace. Massage can be begun at the end of ten weeks or three months. Gradually he is permitted to walk. The support is worn, from four months to one year. (I am in favor of keeping the brace for a full year.) The process of healing, which is accomplished by formation of bony bridges, should be followed by roentgenograms made at regular intervals. Some advocate hastening bony union by an Albee bone graft. In the opinion of others, this is advisable only in the dorsal region as the graft immobilizes several vertebrae. However, the immobility is not harmful as the dorsal region has normally very little motion. In the cervical and lumbar regions, which are more mobile, it is a question whether it is not better to allow nature to stiffen only two vertebrae instead of using the graft operation which stiffens many.

Osgood's<sup>3</sup> opinion in the matter is:

It is undoubtedly justifiable in a case of severe fracture of this type with an irreducible kyphosis in a man whose wage-earning capacity entails much bending or lifting of heavy weights for the surgeon to tell the patient that, although he will probably completely recover without any operative procedure, a fusion or bone graft operation which will comparatively

quickly ankylose this portion of the spine is an extra safeguard against future weakness of the back. The decision should rest with the patient, not with the surgeon.

#### THE TREATMENT OF SPINE FRACTURE WITH PARALYSIS

The advisability of laminectomy to relieve the pressure of the cord is still disputed. After the paralysis has been diagnosed as complete or incomplete, the problem arises as to whether the patient will be benefited by the operation.

Elsberg<sup>2</sup> summarizes thus:

Patients with fresh fractures of the spine with cord and root symptoms, should rarely be subjected to operative interference. If a patient has a complete transverse lesion of the cord, operative interference can do no good, and if the signs are those of a complete transverse lesion but the patient has not a complete lesion, there is no harm in waiting. The claim so often made, that if the patient has a complete crush of the cord, the operation can do no harm as the condition is hopeless anyway, and if the patient has not a complete lesion, the operation may do good, is fallacious and should be abandoned.

In the large majority of instances it is advisable to wait, for the patient can be operated upon one or two weeks later if there be an indication for operation, with a better chance of benefit than immediately after the injury has been sustained.

The only patients with a fresh fracture of the spine in whom operative interference might be indicated, are those in whom, in addition to those with the symptoms of a partial loss of function, there is evidence on the x-ray films of a marked deformity of the spinal canal with pressure upon the spinal canal by dislocated bone or bone fragments, and, only very rarely the patients in whom there are severe root pains from pressure of dislocated bone upon one or more sensory roots.

Operation may be of benefit a few months after the injury in patients with persistent spinal symptoms in whom the x-ray shows more or less marked angulation or deformity of the vertebral canal. In these patients, a wide decompressive laminectomy may allow the cord to bulge backward and thus an acute angulation of the cord be relieved.

## TREATMENT OF KÜMMELL'S DISEASE

Steindler<sup>8</sup> says:

Experience shows that the permanent disability from Kümmell's kyphosis is not very high. For compensation one may recommend a partial disability based upon one-fourth to one-third of the working capacity for one to one and a half years, but work may be resumed in part again in from four to six months after the injury, until gradually the worker's capacity increases to permanent value.

*Treatment:* Recumbency in an hyper-extension position on a Bradford frame for six to eight weeks, then patient may be permitted to be up and around wearing a well fitting plaster-of-Paris jacket, later replaced by a corset.

If symptoms persist, operation may be resorted to.

## STATISTICS AND COMMENTS

TABLE I  
NUMBER OF CASES ADMITTED

Year	Total No.	No. of Crush Fractures
1916	4	2
1917	9	4
1918	1	1
1919	4	3
1920	4	2
1921	5	4
1922	11	5
1923	7	1
1924	7	2
1925	9	5
1926	14	4
1927	19	8
1928	6	4
1929	8	4
Total	108	49

TABLE II

Sex	Number	Per Cent
Male	42	86
Female	7	14

TABLE III

REGION INVOLVED ACCORDING TO X-RAY FINDINGS

	Number	Per Cent
1. Cervical 1-4	2	
4-7	13	31
2. Dorsal 1-10	4	
10-12	7	22
3. Lumbar	23	47

TABLE IV  
OCCUPATIONS

Laborer	17
Unskilled worker	2
Driver	3
Students (athletes)	3
Baker	1
Housework	2
Steam fitter	2
Painter	1
Clerk	2
Professional	1
Telephone repairman	1
No occupation	4
Undetermined	10

TABLE V  
CAUSE\*

Direct injury, including falls	37
Indirect injury	7
Diving	3
Unknown	2

\* These statistics are not entirely reliable as most of them were falls from windows and automobile accidents, hence it was hard to get a definite history, whether direct or indirect.

TABLE VI  
SYMPTOMS IN RELATION TO PARALYSIS

With paralysis	24
Without paralysis	25

TABLE VII  
TREATMENT\*

Bradford frame alone	3
Plaster cast	17
Brace	2
Laminectomy operation	9
Bone graft: operation	2
No treatments given	11
Died before treatments given	5

\* After 1918 every patient was placed on a Bradford frame. All these treatments are understood to include the frame. Most of the patients, on whom laminectomy was performed, came in the early years of these statistics. At that time, spine surgery was less highly developed than now.

TABLE VIII  
RESULTS ON LEAVING HOSPITAL\*

	Number	Per Cent
Left before treatment were given	7	14.5
Improved or cured		
(Of these, two had bone grafts)	23	47
Not improved	1	2
Unknown	3	6
Died before treatment was given	5	10
Died after operation	7	14.5
Died from cystitis and bed sores	3	6

\* We tried to trace the 27 cases that are reported as "improved," "not improved" and "unknown." Were able to locate only 13 patients, who reported that the condition remained as reported here. The large number of fatalities after operation is due to the fact that many patients were operated on which, in later years the neurologists and neurological surgeons would have hesitated to submit to such radical treatments, or would have treated conservatively.

## CONCLUSIONS

1. Every case of injury to the spine should be examined with extreme care to rule out fracture.

2. Immediate rest should be instituted until the examinations are complete.

3. If it does not endanger the patient, the roentgenogram should be made immediately; otherwise a delay of twenty-four to forty-eight hours may be deemed advisable.

4. Radiographs should be taken in two views, anteroposterior and lateral. If doubt remains, stereoscope films should be taken as well.

5. If the roentgenogram is negative but the symptoms point to a fracture, another roentgenogram should be made in a few days, as it may then show the lesion.

6. Diagnosis rests on history, localized pain and stiffness of the spine.

7. Fractures of the laminae, transverse and spinous processes, articular processes, the ribs, the bones of the extremities especially the os calcis are frequently present, complicate the prognosis and influence treatment.

8. Treatments: Rest on Bradford frame then plaster jacket or two plaster shells.

9. The conservative treatment is attended by excellent results. Full functional return may be expected after four to six months of recumbency and hyperextension with the spine immobilized in a shell or jacket.

10. Early operation is indicated where the x-ray shows dislocated bone pressing upon the spinal canal.

11. Patient with fresh fractures should rarely be subjected to operative interference. In cases of a complete transverse lesion of cord, operative interference can do no good. In cases of incomplete lesion where there are indications for operation, it is more beneficial to wait two to three weeks.

12. Later nerve operations are indicated in cases of progressive symptoms and where adhesions are present.

13. All patients having injury in the

cauda equina should be operated on, since the nerves of the cauda equina are capable of regeneration.

14. In late cases where pain still exists, nature has not ankylosed the injured region of the spine, and the patient is to return to strenuous back-bending labor, ankylosing operations should be considered. They are likely to save time and allow the patient to labor without apprehension.

## A FEW ILLUSTRATIVE CASES

CASE 1. G. M., male, aged fifty-one, was admitted to Fordham July 10, 1925, a few hours after having been struck by a street car. He was in shock and had complete paralysis of all four limbs and no control of the sphincters.

*Examination* showed that the lesion was in the upper cervical region and roentgenogram showed that there was a fracture of fifth cervical with displacement of the fragments. The patient was put on a Bradford frame, and a jury-mast with traction was applied at once. In four days he showed some power in the left upper and lower extremities. A few days later, he began to show some improvement in the right shoulder. On July 25, 1925, he regained control of sphincters. Power in the lower extremities improved.

In October, 1925, he was taken off the Bradford frame and a Taylor brace with chin piece was applied. The patient continued to improve and could even be put in a chair. He used the left extremities better than the right. He refused to wear the brace in spite of our protest. A leather collar was made for him. He began to walk in February 15, 1926, with a walking table. Put considerable weight on the foot, and on walking put weight on the heels first. He continued to improve and on August 18, 1926, was discharged from the hospital and ordered to come to the out-patient department for treatments.

*Last Note:* January 1927, walked without assistance though he had slight spasticity on the right side. Dressed and undressed himself. Shaved with the left hand. Could use the right shoulder and elbow, but could not flex the fingers well. Was discharged from Fordham Hospital O.P.D. July 27, 1927, using the upper extremities fairly well (Figs. 1, 2, 3, 4).

*Comment:* Although there was evidently



complete paralysis of the extremities and the roentgenogram showed the fracture, the cord was not entirely destroyed. By traction the

was brought to Fordham Hospital where he was kept for three days. He showed no symptoms whatever; the roentgenogram was nega-

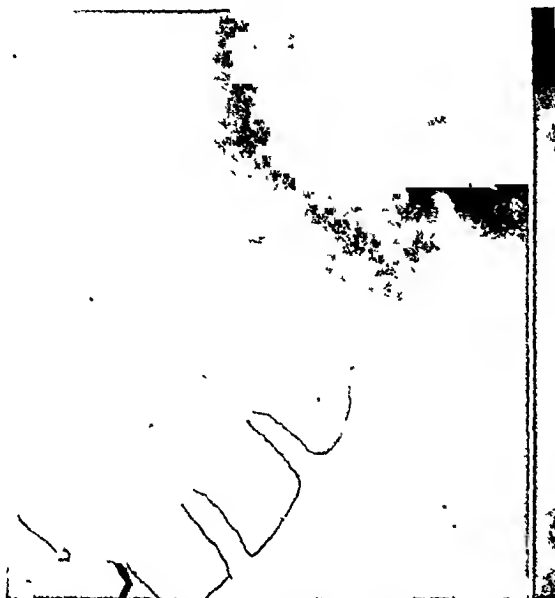


FIG. 1. CASE I. July 10, 1925. Note dislocation of fifth cervical vertebra. (Retouched.)



FIG. 2. CASE I. Sept. 23, 1925. Note good position of dislocated vertebra. (Retouched.)



FIG. 3. CASE I. January 11, 1926. A. Good posture of body and especially good position of neck. B. Ability to raise and rotate left shoulder.

cord was released from pressure. Gradually there occurred complete union of the fragments.

CASE II. S. F., male, aged twelve, sustained an injury to his spine, May 1921, and



FIG. 4. Jan. 18, 1927. Good callus of fractured area.

tive, and he was therefore discharged. (He was not seen by me during his stay in the hospital.)

He came to my out-patient clinic in July, 1921. He then had marked spasm in the

cervical spine. His head was held to the right and flexed forward while the chin turned to the left. Any attempt at motion produced pain.

nearest hospital where he soon regained consciousness. An x-ray was taken immediately and the radiologist considered it negative.



FIG. 5. (Retouched.) CASE II. S. F., Fracture of body of fifth cervical.



FIG. 6. (Retouched.) CASE II. S. F., Nov. 12, 1921, excellent position of vertebrae.

There was tenderness over the spinous process of fifth cervical. The right hand showed weakness in motor power but no definite signs of paralysis. Marked numbness and cyanosis were present. Roentgenogram taken immediately showed a fracture of the body of fifth cervical (Fig. 5). The boy was readmitted to the hospital. A Calot jacket was applied and later changed for a leather collar. He made a perfect recovery in about ten months (Fig. 6).

**Comment:** This case demonstrates clearly that the symptoms of a fracture are often deceiving. Not even the roentgenogram showed the line fracture. It sometimes takes several days to bring out the symptoms and if the case is lost sight of, grave consequences may result. It may be worth while to emphasize the necessity of watching these patients. Relief and recovery were rapid after the application of jacket and collar.

**CASE III.** B. E. F., male, aged twenty-five, salesman, was in an automobile accident on May 24, 1927. Was taken unconscious to the

About an hour later, patient began to complain of pain in back of head and neck. A neurological surgeon happened to be present in the hospital, and was asked by the radiologist to examine the x-ray plates. He diagnosed the case as a fracture dislocation of the fourth cervical on fifth cervical with crushing of the anterior part of fifth cervical. Patient was immediately put on a board.

I was called about three days later. Patient complained of severe pain in the back of head and neck. Any attempt of motion caused spasm. Retention of urine and feces, but no paralysis. Applied a felt collar, the pain was slightly relieved. In two days applied a plaster collar with the neck in extension. The pain was relieved immediately and patient regained control of the sphincters. The x-ray showed that the dislocation had been reduced.

In about two months, the plaster collar was changed for a leather collar. Patient was permitted to walk at that time. In September, 1927, developed osteomyelitis of the lower jaw, probably from marked atrophy of the mandi-

ble. He wore the collar about two years till a bridge of bone was formed across the anterior aspect of the bodies of fourth cervical and fifth cervical. At this time an attempt was made to discontinue the brace, but patient felt dizzy and so it was deemed advisable to continue it for some further time.

At present patient has no pain. Walks without a limp. Motion of the neck is limited in flexion and extension.

Three months after the accident, patient had developed some atrophy of the left calf. In spite of the massage, the atrophy remained and even today there is a difference of  $2\frac{1}{2}$  in. There is also some atrophy of the left upper extremity.

*Comment:* The case was radiographed immediately, but as the radiologist missed the diagnosis that patient was not considered seriously injured. Had not the neurologist seen the x-ray plates, this patient with a serious injury would have been permitted to go untreated and in all probability, the cord injury would have been tremendously aggravated.

The length of time that it took to bridge the bones was about two years.

With conservative treatment cited here, so much improvement, almost complete cure, was obtained.

**CASE IV.** J. K., male, aged fifty-eight, retired. On May 31, 1929, patient was putting up window screen, fell from a first story window and landed on his back. Was taken to Fordham Hospital unconscious. Regained consciousness in the hospital, but had complete paralysis of both lower extremities and loss of control of bladder and rectum. X-ray showed a crush fracture of twelfth dorsal and first lumbar.

Was put at first on a Bradford frame. On the tenth day, a plaster jacket was applied. In about four weeks began to have some voluntary motions in the left lower extremity, a little later in the right. The sphincteric control did not return until very late (about October). He stayed in bed about five months, then was permitted to sit up. Massage was ordered for the lower extremities about the fifth week after the accident. Patient was discharged from Fordham Hospital on August 31 wearing a plaster jacket. By that time the gibbus in the back was corrected. Patient however had a very large and deep bed sore over the sacrum. Had fair power in the thigh and leg muscles, but complete paralysis in all the foot muscles.

On October 2, 1929, patient was fitted up

with a spinal brace and plaster casts to the feet to permit the patient to walk. He found no difficulty in standing in the casts and walking. The casts were opened in ten days and massage and exercises commenced again. In about two months the patient could walk without the casts.

January, 1930: Patient walks freely, though has a steppage gait. Is able to climb stairs. Has no difficulty in walking the street. The feet show fair power in the extensors of the ankle. The bedsore healed completely. Is still wearing the spinal brace.

*Comment:* A patient of fifty-eight, whose resistance was certainly low, sustained a crush fracture severe enough to cause complete paralysis of both lower extremities as well as loss of control of rectum and bladder. Still, with careful treatments, cystitis was prevented, the deformity of spine corrected and complete power of the lower extremities regained.

Both the neurologist and myself were in doubt, even after three to four weeks, as to whether he would make a good recovery. The conservative treatments were however carried out conscientiously and successfully.

**CASE V.** M. A., male, aged thirty-seven, manufacturer. Consulted me on February 11, 1929. About November 11, 1928, was in an automobile accident. Sustained an injury to the dorsal spine. Was able to walk a bit after the accident, but complained of pain in the entire back. Was taken to a small hospital in a neighboring town. Was treated there for four weeks for a sprain in the back. Only then it was noticed that there was a gibbus in the dorsal region. An x-ray was taken and a crush fracture of the tenth dorsal found. A plaster jacket was applied. Patient complained of severe discomfort in the jacket, and had it removed in twenty-four hours. Was without any support for about four weeks longer when an adequate leather jacket was applied. Patient stayed in bed another four weeks and then began to walk around. Came to New York when he consulted me to guide him about further treatments.

*Physical examination* showed a very marked gibbus at the region of the tenth dorsal even when lying on the face. Marked spasm of the entire spine. Could not bend down to pick up objects from the floor. Knee jerks exaggerated. No Babinski reflex. No Oppenheim reflex. No ankle clonus.

Examined the x-ray taken at the first hospital and then the x-ray taken a few days before consulting me. Found that there had been a crush fracture of tenth dorsal. The second x-ray showed that the deformity increased and the anterior portion of the body of tenth dorsal was about one-fourth of normal size. The body of the vertebrae has a mushroom appearance. There were some large spicules in front of the body.

I applied a plaster jacket immediately in marked hyperextension which patient wore without discomfort. Kept the patient in bed for about two weeks then permitted him to walk. Patient wore the cast for three months when it was changed for a brace. By that time, the gibbus has markedly diminished. Spasm was gone and the x-ray showed more density of the bone.

Last note on January 28, 1930: Patient walks without difficulty. There is still a slight gibbus, but not as much as before. Evidence of beginning of ankylosis of the spine.

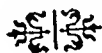
*Comment:* A patient with a definite history of injury to the spine was treated without an x-ray for four weeks. When finally the trouble was discovered and a plaster applied, it was removed within twenty-four hours and allowed to go without a support.

Even after a delay of three months, a good jacket corrected the deformity and prevented further bony changes.

I wish to thank Drs. Nicoll and Cunniffe, the Surgical Directors of Fordham Hospital for permission to make studies of their cases. For the assistance of the roentgenologists, Dr. I. J. Landsman and Dr. H. Hirsch, I also acknowledge my indebtedness.

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# PERIARTERIAL SYMPATHECTOMY\*

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PAIN in the extremities has always been a problem of great concern to the practitioner of medicine, and particularly so when it is recognized as being of vascular origin. Like all other problems which have been difficult to relieve, there has been much investigation and theorizing as to the cause and relief.

Neurovascular physiology is still somewhat indefinite, although there have been numerous experiments and much work done in this field. Of all the older theories advanced relative to the vasodilatation and vasoconstriction of blood vessels, about the only one which has stood the test of time and modern investigation has been the work of Claude Bernard<sup>1</sup> whose investigations were begun in 1852. However, it is interesting to note that Senac<sup>2</sup> in 1749 thought that the rhythmical contraction of the blood vessels was brought about by a "succus nervus" which was secreted from the nerves and acted as an astringent on the vascular wall, and though somewhat modified, the modern theory of Lewis<sup>3</sup> as regards vasodilatation, has a similar basis.

Claude Bernard<sup>4</sup> was the first to demonstrate that there was a change in temperature locally after section of the local sympathetic supply, and it was his thought which is accepted at present that the elevation of temperature was due primarily to the vasodilatation. It was Claude Bernard<sup>5</sup> who introduced the term vasodilator nerves.

As early as 1851 Wharton Jones<sup>6</sup> demonstrated that section of the sciatic nerve was followed by vasodilatation in the area of innervation. This experiment was confirmed by Claude Bernard<sup>7</sup> as well as by numerous other investigators.

Much investigation and work have been done to establish the central course of the vasomotor nerves. At the present time it is

a general consensus of opinion that there exist superior centers in the brain and midbrain and that the fibers pass to the lateral sympathetic nucleus which is located in the posterior horn of the spinal cord. From this nucleus they pass through the anterior root bundles and the rami communicantes albi to the ganglion of the sympathetic trunk where the nerves for the extremity are interrupted and a new neuron is continued through the rami communicantes grisei to the periphery. The sympathetic centers for the visceral organs on the other hand are supposed to lie in the innervated organs themselves (Auerbach).<sup>8</sup>

This explains to a certain extent the physiology underlying the vasoconstrictor group of nerves which are the nerves involved in the pathology where periarterial sympathectomy can produce relief. The vasodilator nerves have not been so clearly elucidated although the work beginning with Claude Bernard was carried on by Lovén<sup>9</sup> in 1866 when he described a reflex known as the Lovén reflex. This reflex is produced by the stimulation of the central end of a cut sensory nerve producing vasodilatation in the adjacent area. This phenomenon as observed by later workers holds good for veins as well as for arteries.

Work upon this group of nerves has been continued on up to the present time with much controversy and theorizing. The generally accepted opinion now seems to be that of Ostrumow,<sup>10</sup> according to whom the dilators act as inhibitory nerves on the tone of the constrictors. Lapinski<sup>11</sup> carried this work further in 1926 but at the end of his work he denied the existence of the vasodilator nerves. However, Ostrumow probably has the most rational theory, that is, that the vasodilator nerves depress the tone of the constrictor nerves,

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and it is the interference in this tone of the constrictor nerves which makes relief possible from a periarterial sympathectomy. On the other hand, Lewis and Hanner<sup>12</sup> have some following in their theory that the nerves secrete a vasodilator substance which they call the "H" substance and which is identical with histamine. Histological observations which have been made in an effort to answer the question of degeneration of denervated muscles of the vessels have not agreed. For, Lapinski<sup>13</sup> in 1900 made observations that would indicate that the degeneration took place. But in 1903 and later Floresco<sup>14</sup> and other workers were unable to confirm Lapinski's observations, although Brandsburg<sup>15</sup> in 1925 records a degeneration of the muscle of the heart four months after extirpation of the sympathetic.

Anatomically the generally accepted theory is that of Leriche,<sup>16</sup> although physiologists who have worked upon this subject not only fail to agree with each other as regards the long perivascular tracks with peripheral nerve centers but disagree with Leriche and Policard<sup>17</sup> whose investigations were done on human beings. A combined study of this subject, that is, a study including both anatomical and physiological observations, has only been carried on by three investigators, Lapinski<sup>18</sup> in 1905-06, Hofmann<sup>19</sup> and Engling<sup>20</sup> in 1907-08, and Woollard<sup>21</sup> in 1926. Lapinski's work being the first done combining both anatomy and physiology proved that the vasomotor nerves in the dog ran in the sciatic nerve. Hofmann and Engling after their investigation felt that the peripheral ganglionic nerve nets in the sense of Bethe cannot exist. Their investigations were rather indefinite and are not conclusive. Woollard in 1926 attempted to show that the impulse travels to the vessels perivascularly along the peripheral nerves and he also felt that the trophic innervation of the vessels of the extremities cannot at any rate be perivascular. Of these three workers only two, Lapinski and Woollard, give us any definite informa-

tion relative to the anatomy and physiology of vascular innervation. Since their experiments were carried on in cats and dogs I feel that the observations made by Leriche and others who have worked with him on the human being are perhaps worth more to us who are working on human beings also.

Leriche and Fontaine<sup>22</sup> have offered a theory which does not wholly disagree with the experimental, anatomical theories of other workers. Their theory avoids criticism because it is based upon observations that were made on human beings. These observations led them to believe that the motor innervation of the vessels is due to peripheral nerve plexuses in the arterial wall itself; also that the extrinsic nerves in the vessels play the rôle of associated fibers with pressor and depressor effects. They think also that the vasomotor reaction should be considered from two standpoints, namely, its influence upon (a) the general circulation and (b) the local circulation of the limb operated upon.

This first-named reaction was particularly noticeable in 1 patient I operated on for frostbite. The patient had a bilateral gangrene of his feet. A periarterial sympathectomy was performed on the left side with a ligation of the femoral vein. Immediately postoperative there was a marked increase in the circulation on the operated side with an increase in circulation on the opposite side which was not operated. This improvement was manifested by a definite hyperemia and an increase in temperature of both feet and legs. Although the gangrene was the same in both feet, the side that was operated on healed with skin graft, the patient only losing the toes at the metatarsophalangeal joint. The improvement in circulation in the side not operated on continued as it was immediately postoperative for a period of ten days, after which time the foot progressed on to a complete gangrene and amputation was necessary. I now feel that if I had done a bilateral periarterial sympathectomy in the beginning I might possibly have saved

the same amount of both feet, but I was anxious to make a comparative observation and this was an ideal case for the observations.

I have usually ligated the femoral vein at the time the sympathectomy was performed. This procedure certainly increases the hyperemia and in one case the pain was not controlled until a second operation was performed and the vein was ligated. This was a case of Buerger's disease. Lipschutz<sup>23</sup> reports unfavorable results with ligation of the femoral vein in Buerger's disease. However, Dean Lewis<sup>24</sup> ligates both vein and artery and reports good results. Also van Gorder<sup>25</sup> felt that the ligation of the vein in thromboangiitis obliterans is justifiable and that pain and gangrene will not be controlled until this is done.

Jaboulay<sup>26</sup> performed the first periarterial sympathectomy in 1899, and his results clinically were unsatisfactory. The operative procedure remained more or less status quo until 1913 when Leriche drew attention to the procedure and began to stimulate interest. However, very little interest was stimulated in this country until 1921 when Leriche<sup>22</sup> reported before the American Surgical Association the results in 64 operations. Since that time much work has been done in this field by various surgeons both here and abroad, many of whom have been pupils of Leriche. More recently Leriche<sup>28</sup> presented another paper before the American Surgical Association in which he reported 400 operations, 298 of which were performed upon the periarterial sympathetic. In this large series of cases he has operated for a varied number of pathological conditions.

Hey Groves<sup>29</sup> who has visited the Leriche Clinic at Strasbourg classifies Leriche's indications for operation under five headings which seem to cover the many conditions to which the operation has been applied so far and given results. These five headings are: (1) pain; (2) vasomotor phenomenon; (3) injuries and disease of the arteries and veins; (4) chronic and

trophic ulcers; (5) bone and joint disorders. The last-named group Leriche has described with rather startling results as far as relief of pain and overcoming destructive bone changes which were demonstrable by x-ray.

It is interesting to note that Leriche<sup>30</sup> feels that periarterial sympathectomy differs from ganglionectomy only quantitatively, and not qualitatively. The ganglionectomy gives a more marked and more permanent result.

In my own group of cases which consists of 9 operations on 8 different patients there were 2 operations for trophic ulcer. Both ulcers were located at the base of the great toe, one on the right foot was three and one half years old, and the other on the left foot was of three years' duration. Both had received treatment, that is, curetting, strapping, cauterization, and various ointments without evidence of cure. They were practically the same size and both responded to periarterial sympathectomy. The right femoral vein was ligated and the right femoral artery was denuded of its adventitia for a distance of about 10 cm. The left femoral artery was denuded of its adventitia for about the same distance but the left femoral vein was not ligated. The ulcer upon the right side healed completely in three weeks while the ulcer upon the left side took almost four weeks to completely heal. The ulcer remained healed after the patient returned to his home until his death about a year later from a general carcinomatosis which was proved by an autopsy.

There was 1 case of varicose ulcer which was treated by sympathectomy on the femoral artery and ligation of the saphenous vein. This patient is cured and I hope will remain so although it is a bit early to make any definite statements.

There was 1 case of a patient having arteriosclerosis and diabetes who had a ligation of the femoral vein and periarterial sympathectomy. He was not relieved although there was a marked change in the temperature of the leg after the

sympathectomy. His pain persisted but not quite as severely as prior to operation. The gangrene of his great toe which was present prior to operation progressed on to the point where it was necessary to amputate his leg. This patient died a year and a half later from his diabetes and senile dementia. I believe that had a ramisection been performed upon him he would have gotten relief from his pain as well as from gangrene. Another patient having arteriosclerosis with an unhealed wound following an amputation of the great toe three years prior to the sympathectomy had definite relief from pain and a gradual healing of his wound. He had both periarterial sympathectomy and femoral vein ligation.

There was 1 case of Raynaud's disease which was not of the blanching type. This patient was not relieved in any way and the condition progressed on to amputation and death from pneumonia a few weeks after his extremity had been amputated. The femoral vein was not ligated in this case.

There were 2 cases of frostbite and in 1 case as we have already explained the results were good. The other case we considered a failure although there was apparently a definite limitation of the gangrene for a period of three weeks. The foot became markedly swollen and bone involvement was present to such an extent that amputation was advisable. This patient had a four plus Wassermann reaction which may or may not have had something to do with the failure.

There was 1 case of endarteritis obliterans which was not relieved after periarterial sympathectomy upon the femoral artery had been performed, although about 9 cm. of the adventitia were removed. There was slight improvement in the pain of the foot and the partial gangrene which was present on four of the toes did not progress any further or did it clear up.

Three weeks later a second operation was performed on this patient and the femoral vein was ligated. After ligation of the femoral vein there was a marked increase of the hyperemia of the foot and the gangrene present in the toes cleared up. The patient slept comfortably at night without narcotics. About eight weeks after the operation two toes underwent a dry gangrene change and were amputated. Since amputation, the patient's pain has returned, the wound has not healed, and the gangrene has extended up his foot. I now feel that this patient needed a more prolonged effect and should have had a ramisection.

In the summary we might say that the anatomical investigations indicate that the nerves are divided morphologically into two groups: (1) nerves having free endings, most frequently medullated to their termination. These are found on the larger vessels and entirely in the adventitia; (2) nerves which are non-medullated but characterized by the formation of peripheral nerve nets and extend down between the muscle cells.

Physiologically: (1) the reticular nerves of the blood vessels are of a sympathetic nature and their function is mainly vasoconstriction. They also have vasoconstrictor tone. (2) Vasodilator nerves function by antidromic conduction and are probably identical with ordinary sensory nerves. (3) Physiologists for the most part deny the existence of long perivascular nerve chains, but this is not true according to investigations on human beings made by surgeons working in this field. (4) Periarterial sympathectomy does produce a hyperemia lasting usually eight weeks. It does relieve pain. The operative procedure is simple and has very little risk to it. There are many conditions to which the procedure has been applied with definite relief and often cures.

[For references see p. 79.]





# RECURRENT RENAL CALCULUS:

## ITS CAUSE AND PREVENTION\*

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THE recurrence of renal stone after conservative operation for its removal occurs in over 15 per cent of cases. These may be divided into two groups, the true and false. True recurrence is a new formation of stone after its complete removal. False recurrence is not a new formation, but the persistence of stones missed or left behind at the time of operation, the so-called left-overs. The false form has been the more frequent finding in the past. Today the use of the x-ray at the operating table has materially reduced its incidence.

The recurrence of renal stone is dependant upon many factors, both primary and contributory.

The causes of primary renal calculi have a bearing on the causes of recurrent stone and will be considered first.

It is possible that the coagulation of colloids with precipitation of the crystalloids may occur without any other disturbing element and although this is unlikely, it is difficult to disprove.

Infection undoubtedly plays an important rôle as an exciting cause. This is evidenced by the frequency with which it is found in stone-bearing kidneys. The experiments carried out by Rosenow and Meisser emphasize the part played by bacteria in the production of renal calculi. Rosenow and Meisser implanted a strain of green streptococci into the pulp cavities of the teeth of six dogs, which were then sealed with dental amalgam. This culture was obtained from the urine of patients with urinary lithiasis. Five of these dogs developed renal calculi.

This experiment is striking and demonstrates the selective action of these organisms. It also emphasizes the important part played by infection in producing renal calculi.

Impaired drainage is of considerable importance in the production of stones, and although it is believed by many that retention must be associated with infection in order to produce them, nevertheless there are many cases in which stones are found in the urinary tract, the urine from which is sterile.

Concentration of the urine is an important factor in the development of urinary lithiasis. This is evidenced by the fact that it seems to be more commonly found among people living in hot dry zones. Here the skin eliminates a large percentage of the water, leaving the kidney to deal with a very concentrated urine most of the time. Mr. R. Campbell Begg, a urologist of Wellington, New Zealand, who served with the English Army in Mesopotamia, told me that the temperature in this region during the day rises to 130°F. in the shade, cooling off at night to about 100°F. He stated that in this temperature urination was rarely resorted to, due to the fact that most of the water is eliminated by the skin and that the incidence of stone among the natives was nearly 100 per cent, undoubtedly due to concentration. It is said that surgeons are commonly affected with urinary stone because of their excessive perspiration during the time spent in the operating room, and their failure to make up for this loss by an extra intake of water. There is little question that many people, especially during the cold months of the year, fail to take sufficient fluids to prevent concentration of urine, thus making themselves more susceptible to the formation of stones.

Urinary stone seems to be more prevalent in certain localities. In some places an explanation can be given for this, while in others there does not seem to be any definite reason. For example, in certain

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parts of Africa, especially East Africa, the parasite *Bilharzia hematobia* has something to do with the production of stone. Naturally, urinary lithiasis is frequently found in localities where these parasites are native.

The character of the drinking water is also said to have an influence on the causation of urinary lithiasis, and in vicinities where the so-called hard water (water containing large amounts of calcium and magnesium salts) is drunk, urinary stones are supposed to be widespread. This is questionable.

Heredity is also thought to be a contributing cause, but this is doubtful, with the possible exception of cystin stones, which have been found not infrequently in more than one member of the same family.

Again, diet is given credit as a contributing agent in the formation of stones, undernourishment, especially a vitamin deficiency, being charged up to those cases which occur in childhood.

Although the foregoing factors may play a minor part, operative trauma, cavity formation and disturbed drainage with infection offer the most logical explanation in the causation of recurrent renal calculi.

#### OPERATIVE TRAUMA

Whenever we are forced to disturb the renal parenchyma in the removal of stone, we offer an opportunity for recurrence. Therefore pyelotomy when surgically possible, is a better procedure than nephrotomy. There are calculi which cannot be removed through an opening in the pelvis, particularly the cases of large branched stones and stones locked in the parenchyma. Some stones locked in the parenchyma, the so-called silent stone, in certain circumstances should not be removed. I refer particularly to small or moderate sized stones in the parenchyma, discovered by the x-ray, which neither cause symptoms nor disturb the chemistry of the urine, nor reduce the renal function. While these stones often remain quiescent for

years, or even throughout life, nevertheless these patients should be observed from time to time. In order to remove these silent stones incision of the parenchyma is necessary, and the trauma produced predisposes the patient to recurrence, and the recurrent stones in all probability will impair the integrity of the kidney. Injury to the mucous membrane lining the pelvis and calyces during the removal of stones gives an opportunity for recurrence; therefore care should be exercised in such removal, especially in passing forceps into the calyces.

The cleansing of the pelvis and calyces following the removal of stones is of great importance. The leaving behind of sand, small particles of stone, fragments of tissue and blood clots is likely to be the cause of recurrence. The lavage of all cavities in the kidney with saline solution before completing the operation is important.

Incrustations should be removed, and when ulcerations are found they should be curetted as they offer a good bed for the re-formation of stone.

Stones located in a lower or upper calyx which have produced dilatation of the calyx, or have destroyed the parenchyma with cavity formation, are better treated by resection of the involved part of the kidney than by pyelotomy or nephrotomy, because a dilated calyx or a cavity offers an excellent opportunity for more stones to form.

Unwarranted fear of hemorrhage or leakage following resection has greatly limited the use of this valuable operation in treating these cases. We have demonstrated by experiments on a series of dogs, that renal resection does not offer any serious danger of either postoperative hemorrhage or leakage of urine. This procedure is also useful in the treatment of calculi located in one part of a double kidney. Anomalies such as double kidney seem to predispose the patient to stone formation. If one part of such a kidney contains stone and the other is free, a resection may offer a better chance for

permanent cure than just the removal of the calculi, providing the operation is anatomically possible.

Interference with drainage is not uncommonly caused by an abnormal position of the kidney. This abnormal position pro-



FIG. 1A. Case of calculous pyonephrosis, showing marked changes in pelvis and calyces.



FIG. 1B. Improvement of case shown in Fig. 1A following drainage and lavage with ureteral catheter, making for safer operation for removal of calculi.

The drainage from a stone-bearing kidney following operation must be adequate, since faulty drainage is certain to be a predisposing cause of recurrence.

The interference with drainage may be located any place along the urinary tract from the distal part of the urethra to the neck of a renal calyx. In addition to the correction of the obstruction, at the time of operation it is our duty to see, by postoperative roentgenological study and further dilatation if necessary, that the obstruction does not recur.

Not infrequently a calyx containing a stone has a narrow neck. This should be thoroughly dilated at the time the stone is removed.

A narrowing at the ureteropelvic junction is a common factor in the causation of stone. If found, this should be corrected at operation by a thorough dilatation or possibly a plastic operation, and it should be dilated subsequently if narrowing recurs.

duces an awkward relation between pelvis and ureter with resulting poor drainage. It is therefore of the utmost importance to place the kidney, following the removal of stone, in a position as near the normal as possible. It is a mistake following any operative procedure on the kidney to drop it back and allow it to take any position it may happen to fall in. If it does not remain in a normal position after replacement, it should be sutured in place.

An overlooked stone in the ureter may interfere with drainage from a stone-bearing kidney and may be the cause of recurrence. Therefore careful preoperative search should be made, and if a stone is found, removed before or at the time of removal of the renal stone.

Stones in the ureter are likely to produce a rather severe trauma to the wall of the ureter, particularly if they become impacted. For this reason ureters should

be subjected to postoperative study and if any narrowing occurs, dilatation should be practiced to prevent retention of urine

be destroyed, and may make the removal of the stone a safer procedure.

If any infection remains following oper-



FIG. 2A. Bilateral ramshorn calculi.

and recurrence of stone. Narrow areas in the ureter whether due to stricture or conditions outside the urinary tract should be corrected at operation or immediately after.

#### INFECTION

Knowing the important part played by infection in stone production, it should be our aim to remove all possible foci of infection before any operation on the kidney is attempted. If we are dealing with an infected stone cavity it should be resected if surgically possible. If not, and the kidney appears worth conserving, drainage should be instituted.

In cases of severe calculous pyonephrosis, preoperative drainage and lavage by means of the indwelling ureteral catheter may offer an excellent opportunity of converting an infected organ into a clean one, and greatly reduce the operative danger and the possibility of recurrence. Catheter drainage of this kind may help to conserve a kidney which otherwise might



FIG. 2B. Stone fragment left behind in lower calyx, following operative removal of stone from left kidney of case shown in Fig. 2A.

ation, lavage and drainage of the renal pelvis and calyces by means of a ureteral catheter should be carried out until the kidney urine is sterile. These infected kidneys deserve carefully carried out post-operative study over a long period of time in order to prevent recurrence of stone from infection.

#### NEPHRECTOMY

One of the difficult problems in the prevention of stone recurrence is the question of indication for nephrectomy. Here one's surgical judgment is often sorely tried. The preoperative pyelographic, functional and bacteriological studies are of vital importance, but at times even with the knowledge of these findings, it is necessary to make the decision between removal of stone and nephrectomy after the kidney has been exposed.

Although cystinuria and the formation

of cystin stones are comparatively rare conditions, they occur sufficiently often to deserve consideration. The removal of

1. They may fail to produce a shadow on a film taken with the kidney in the body.
2. Two or more stones may be super-



FIG. 3A. Impacted stone in left ureter, numerous small stones in upper part of ureter, large stones in pelvis, and small stones in calices.

these stones by surgical methods other than cystoscopic should be avoided if possible due to the fact that these patients continue to have excess of cystin in the urine throughout their lives and once surgical methods are instituted their problem becomes more and more difficult. Recurrence is almost certain. By keeping the ureters well dilated these patients will pass fairly large stones and some that are too large to pass may at times be broken up by catheter manipulation because they are soft as long as they remain in the body, becoming very hard on drying.

Undoubtedly one of the most important factors in the recurrence of renal calculi is the failure to remove all stones or fragments. Even in cases which have been subjected to a most careful preoperative roentgenological study, stones are very apt to be overlooked for the following reasons:



FIG. 3B. (Same case as shown in Fig. 3A.) Film of left kidney taken on flank during operation, showing one stone still present in middle calyx.

imposed on one another, producing one shadow.

3. When a stone is removed, especially with instruments, a small piece or pieces may be broken off and left behind and promptly cause recurrence.

4. They may be seen on the film but not found at operation.

Practically all of these conditions may be avoided by fluoroscopy of the exposed kidney before its replacement as described by Braasch;<sup>1</sup> or better still by placing a small film behind the delivered kidney and exposing it to the x-ray as described by Quinby.<sup>2</sup> This small film in all probability will show any stone or fragments which have been overlooked and will help in locating those which have eluded the operator. If this method is carried out routinely, the cases of recurrent renal calculi will be greatly reduced. The use of these methods is not a refinement but an absolute necessity in the surgery of renal calculi.

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# UNDESCENDED TESTIS

## REVIEW OF THIRTY-TWO OPERATIVE CASES\*

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THE subject of undescended testis has interested mankind for many centuries and the literature abounds with references to this peculiar anomaly. The condition of retention was recognized long before Hunter in 1786 gave the subject great prominence. It is said that Tamerlane, the Conqueror of Western Asia in the 14th century was afflicted with the deformity. Paré made references to it in his writings. Koch of Munich was the first man to have operated (in 1820) for correction of the malposition. Emperor Constantine forbade under penalty of ostracism any person who, undertaking the operation for radical cure of hernia, performed castration. Sixtus v in 1587 prohibited men having undescended testes from marrying under penalty of excommunication.

The etiology of undescended testis is obscure. Imperfect development and dysfunction of the gubernaculum and imperfect development of the scrotum have been suggested as prominent factors. Küttner thinks retention is due to shortening of the spermatic cord. Fetal peritonitis causing peritoneal adhesions is given as the etiology by others.

Grossly, the undescended testis is subject to great variations in consistency and shape. Thus it may be normal in size or show variations from slight to complete atrophy and may be soft and flabby or firm and fibrotic. While Hunter regarded an undescended testis as "exceedingly imperfect," it has been abundantly shown that such a testis may not necessarily be too seriously damaged and that any considerable changes in its structure are secondary and for the most part dependent upon persistent malposition. This view has recently gained great weight by the experiments of Moore at the University of Chi-

cago, Wangenstein at the University of Minnesota and by others in this country and abroad. Thus, it has been shown in dogs, cats and other experimental animals, that the normal testis which has been transplanted into the abdominal cavity undergoes atrophy and loses its spermatogenic function in a comparatively short time and will show degenerative changes in the seminiferous tubules and furthermore that replacement of the damaged organ into the scrotum causes reestablishment of the spermatogenic function and a restitution to normal of the histological picture. According to these investigators, the intra-abdominal temperature is too high for the proper function and development of the testis and as a result degenerative changes occur within two weeks in normal testes that have been transferred to the abdomen. The lower temperature of the scrotum thus seems essential for normal and complete spermatogenesis. The scrotum is well equipped for local heat regulation. There is no insulating layer of fat between the skin and the dartos muscle. A heat regulatory mechanism is further suggested anatomically and physiologically by the laxity of the scrotum and the fact that through the medium of the dartos and the cremasteric muscles, the testis moves independent of voluntary control. Thus in a cold environment, the testis is held in a high scrotal position and when exposed to warmth, it lies in a dependent position. Whether the thermal theory is correct or not, the scrotum seems necessary to a maintenance of a normal histological picture in the testis. If then a normal anatomical position of the testis is necessary to its complete growth, it is logical to assume that full development of the retained testis may best be facilitated by its opera-

\* Read at the meeting of the Brooklyn Surgical Society, October 2, 1930.

## Goetsch—Undescended Testis

tive replacement in the scrotum before it is seriously damaged. It has long been taught that the testis has two main functions.

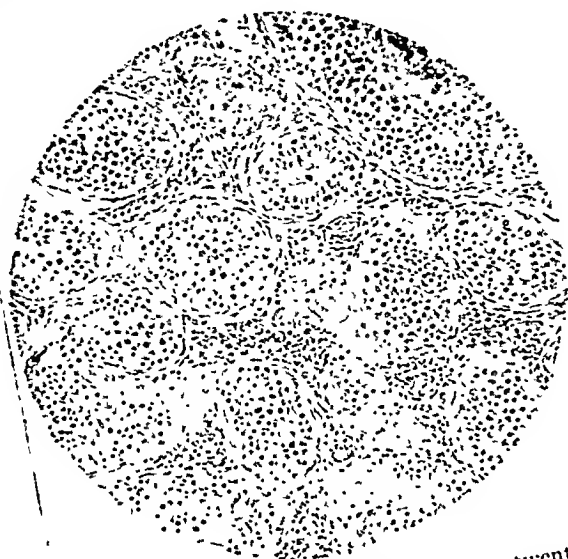


FIG. 1. Normal testis ( $\times 130$ ) from man twenty-one years old, showing generous distribution of essential elements, both parenchymatous and interstitial. (Department of Anatomy, Long Island College Hospital.)

Primarily through its germinal epithelium, it is a spermatogenic organ and secondarily through the interstitial cells of Leydig, it is responsible for the development of the secondary sex characteristics.

Much controversy has taken place regarding pathological changes that take place in the undescended testis. Hunter, as previously noted, stated that the retained organ was structurally imperfect. Astley Cooper taught that all bilateral cryptorchids had loss of reproductive power due to absence of spermatogenesis, whereupon one of his pupils, a cryptorchid, committed suicide. However, histological examination in this case showed evidence of spermatogenesis in both testes. Cooper's view is practically universal although Brunzema cited the case of a patient with bilateral cryptorchidism who having had no children by his first wife, married a second time and became the father of four children. This brilliant accomplish-

ment may be open to various interpretations. Bilateral cryptorchids though they usually lack spermatogenesis are by no means necessarily lacking in sexual power.

Southam and Cooper in 1927 showed that at whatever position the prepuberty testis is arrested, it is (in many areas at least) frequently identical in structure and relationship to that of the corresponding scrotal organ. The younger the age at which a retained testis is examined, the more nearly normal are the structural elements apt to be and conversely the longer a testis remains in an abnormal position, the more likely will there be degenerative changes.

The changes found in retained testes are recognizable more and more as puberty approaches and usually are most marked in testes arrested in the abdomen and the higher parts of the inguinal canal. There is a gradual dissolution and atrophy of the tubules and if the process continues, the tubules may disappear entirely, and later there is more or less replacement fibrosis.

The interstitial cells of Leydig are apparently not greatly influenced by the abnormal position. They are in abeyance during early childhood and appear normally in greater numbers at puberty and in adults. Frequently, in the undescended testis, there is an apparent overproduction of the interstitial cells which is doubtless more relative than actual owing to the less numerous and smaller spermatic tubules.

Undescended testis occurred in the proportion of 5 to 1000 in Scotland among recruits in 1916 and 1917 and 2 to 1000 among Austrian recruits. The American War Department gave the ratio as 3 to 1000 among our own recruits. In general we may say that unilateral or bilateral cryptorchidism occurs roughly five times in 1000. This was Kocher's estimate. The matter therefore warrants our serious consideration. Right-sided arrest occurs much more commonly than does left-sided. This may be in agreement with the fact that the left testis usually descends somewhat earlier than the right.



## COMPLICATIONS

*Malignancy:* No greater diversity of opinion exists about anything in surgery than the question of malignancy in the undescended testis. Certainly the older teaching that there is an increased tendency to malignant degeneration in the undescended testis is open to grave doubt. Thus in 62 cases of abnormally placed testis, Büdinger found only 1 case of malignancy and during the same period he noticed 8 cases in normally placed testes. In 1923, Tanner reported a case of bilateral teratoma testis of a carcinomatous nature in a person with normally descended testes, and in 1915 Coley cited a case of bilateral abdominally placed testes with malignant degeneration. Eccles reported the occurrence of undescent 854 times in the examination of 74,800 patients with hernia. Yet, in the entire series there was not a case of malignancy. In 46 cases of sarcoma of the testis observed during a period of twenty-five years previous to 1919, Cunningham had never seen a case of malignancy develop in an undescended testis. However, since that time (i.e., up to 1924) he had seen 4 cases. He was thus unable to draw any conclusions. Hinman, however, emphasizes the susceptibility of the abnormally descended testis to malignancy and urges the necessity of operative intervention before puberty. Malposition may present theoretical factors predisposing to malignant change. Thus when a testis is resting in the inguinal canal or near the external ring, it is constantly exposed to repeated trauma, irritation and pressure which if unrelieved, may tend to malignant degeneration, just as these same factors are said to produce malignancy elsewhere. Von Kahliden pointed out that abdominal testes are not as apt to develop malignancy as the inguinal ones that are exposed to trauma and irritation. Szymanowski, a colleague of Pirogoff, died of metastases following an operation by Pirogoff for malignant degeneration of the left inguinal testis. Possibly if he had been given the benefits

of operative scrotal replacement in childhood, he might have been spared this fate.

*Hernia:* During fetal life, an evagination of peritoneum, the processus vaginalis, is projected into the inguinal canal. The testis gradually descends from its original position below the kidneys and migrates through the inguinal canal into the lower limits of the scrotal pouch where it is held at birth or soon after presumably by the gubernaculum testis. With the complete descent of the testis, the processus vaginalis fuses throughout its inguinal and scrotal portion excepting at the lower end, where it forms the tunica vaginalis testis. Complete fusion of the process occurs only when complete descent of the testis has taken place. Hence a congenital hernial sac is practically always found in association with a true undescended testis. This being the case, certain dangers are constantly present. Thus incarceration and strangulation of the associated hernia may take place as happened in 3 cases in our series (roughly, 1 in 10). (Table 1.)

*Torsion:* Torsion of the cord seems more prone to occur in undescended testes than in those that occupy normal positions. Torsion occurred twice in our series (in the ratio of 1 to 16). (Table 1.) Torsion of the testis and strangulation of the associated hernia may be hard to differentiate as both cause pain, nausea and vomiting and local swelling. Ileus usually is absent in torsion. However, in either event, procrastination is dangerous and emergency operation should be resorted to as soon as possible.

*Hydrocele:* Hydrocele is a comparatively frequent complication. In 1 case in our series, a right ectopic testis was found projected above the external ring over the external oblique muscle and was accompanied by a huge hydrocele of the cord that was carefully excised en masse and was by actual measurement 14 cm. in length (Fig. 4). The testis was slightly undersized and was brought down to a midscrotal position by means of the Bevan technique.



*Nervous Disorders:* Certain clinical findings have long been known to accompany undescended testis. Enuresis was relieved

in our series; once in striking fashion. In 1 case, a boy of fourteen years with bilatera undescent, there was great mental defec



FIG. 2. Boy, aged fourteen. Bilateral undescended testes. Stigmata of degeneration. Bilateral ptosis, left internal strabismus, large ears, thick lips, flattened nose, etc.

in 1 case of Brunzema by scrotal replacement of an undescended testis. We had one similar experience. In a boy nine years of age who had been unsuccessfully treated for bedwetting, there was prompt cessation of the enuresis after low scrotal replacement of the undescended right testis. Hypothyroidism seems to accompany the condition in some cases and the literature contains a number of references to cases in which thyroid extract acted favorably upon imperfect descent. We have not had this experience. There is a tendency to the eunuchoid type of individual in some cases. Marked stigmata of degeneration have been associated with bilateral undescent. We met stigmata in mild form several times

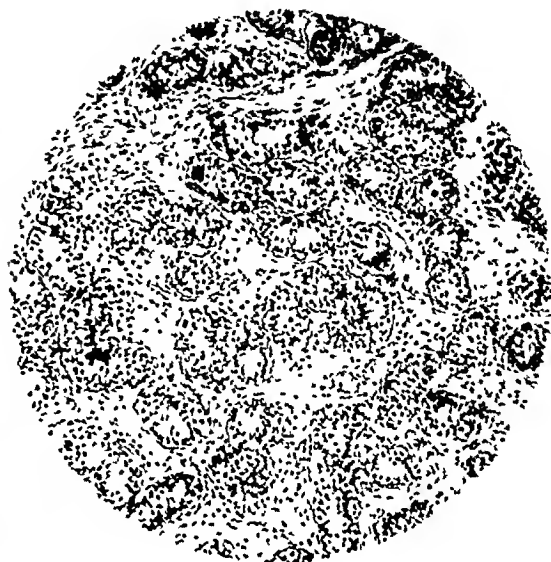


FIG. 3. Section from testis of patient shown in Fig. 2. Notice degeneration and decrease in size of tubules but persistence of interstitial cells notwithstanding poor type of individual, bilateral undescent, stigmata, etc. Even in most unfavorable cases, testis is thus not a total loss. Sections from more favorable cases show more normal histological picture.

tiveness, bilateral ptosis of the upper eyelids, left internal squint, large thick ears and lips, flattened nose and other stigmata of degeneration (Figs. 2 and 3). One-sided undescent is not so frequently associated with stigmata although neurotic disturbances are frequently present: chorea, mental deficiency, epilepsy and perverted personality may occur. Thus, in a boy at puberty in whom I found the right undescended testis completely atrophied and recognizable merely as a fibrous nodule as large as a wheat grain, there was marked personality change. The boy was a mischief-maker, had certain bullying tactics especially when dealing with younger children and showed marked thieving and lying propensities and had some of the characteristics of a sadist. It is interesting that his left testis was markedly oversized (compensatory hypertrophy?).

In postpuberty cases, neurotic manifestations varying from slight worry and

mild depressions to symptoms approaching frank sexual neuroses are present very often. Some adults fear lack of sexual power and the ability to procreate and are apt to become depressed and even morose. Singularly, in 1 case a bilateral cryptorchid of twenty-eight years that I have had under observation at intervals for the past six years, there is marked development of the secondary sex characteristics with possibly even more than average sexual power. The patient is very muscular and robust, has an abundance of abdominal and general body hair and is in no way nervous or neurotic. Numerous examinations in New York and elsewhere have failed to demonstrate spermatogenesis (Fig. 6). This fact is more of a worry to his wife than to himself.

#### OPERATIVE TREATMENT

Up to 1898 when Bevan first described his operation for undescended testis, most patients were advised against operation owing to the generally unsatisfactory results that followed failure to obtain satisfactory mobility and proper replacement. The testis was quite often sacrificed because it was believed that ultimately it was destined either to complete atrophy or malignant degeneration. Also removal was said to greatly facilitate the repair of the accompanying hernia.

Sacrifice of the testis is advocated in some rather recent texts. Thus for example, Rose and Carless state:\* "Taking into consideration the discomfort occasioned by the condition as well as the risk arising from the tendency to malignant disease, there can be no doubt that the best method of treatment is the removal of the testis." In view of our accumulated knowledge, the practice of removal as a routine measure is indefensible.

The lack of uniformity of opinion regarding indications for and the technique of operative treatment is further emphasized by Hoffstätter's listing of more than 20 operative methods in 1912. These varied

from radical extirpation to various methods of fixation and suspension.

In view of all the past confusion, we must seriously ask ourselves whether we can offer the patient or his physician an operation that will cure the accompanying hernia, if one is present, that will halt atrophy and retraction of the testis and that will give an encouraging number of late results. We believe this to be possible in most of the cases and we believe further that the surgeon can satisfactorily accomplish these results by adhering to the Bevan principles. Moore's experimental work previously mentioned, the presence of an actual or potential hernia in most cases, the psychological and physiological factors and the dangers from trauma and serious complications together with the little likelihood of descent if this has not taken place at birth or shortly after, warrant operative interference as early as feasible. Bevan now places the age of choice at two years on the grounds that the sooner normal anatomical and physiological conditions are established, the quicker normal development will ensue. Bevan's operation aims at sufficient mobility of the testis and the cord and its structures to permit replacement of the testis well down in a newly constructed scrotal pouch without tension and if at all possible without sacrifice of the spermatic circulation.

The series that I am reporting consist of 10 personal cases that I had the privilege of operating upon and 22 others that were contributed by other members of the Department of Surgery at the Long Island College Hospital in the past ten years. In general the principles of Bevan were followed.\* Briefly, the operation is as follows: The usual inguinal hernial incision is made, the inguinal canal is exposed and the vaginal pouch is located and freed. The sac is incised high up and the testis is usually located without difficulty. The

\* A full description of the operation with illustrations can be found in the article by Bevan in Chap. LXI, Vol. 4, of Keen's "Surgery."

\* Ed. 11.

vaginal process of peritoneum is then divided just below the internal ring and well above the testis. The neck is carefully freed from the underlying cord and its structures, and ligated high up as in the ordinary herniotomy. The remainder of the peritoneum is then freed from the cord, and by this procedure more and more mobility is developed. Occasionally, especially in young children, the vaginal process of peritoneum is very thin and firmly adherent to the underlying cord, and separation may be difficult. Bevan facilitates the freeing of the vaginal process from the cord by the injection of normal saline between the peritoneum and the underlying cord. He uses an ordinary hypodermic syringe with a fine needle. The blebs thus formed render the freeing of the cord from the vaginal process a great deal easier. Small fibrous bands about the internal ring or within the cord itself are carefully divided and usually produce complete and satisfactory mobility. In exceptional cases, the spermatic vessels are found unusually shortened and must be divided to obtain adequate mobility. This latter procedure should be avoided if mobility is at all possible without division of the vessels as varying degrees of atrophy of the testis will most certainly follow if the spermatic vessels are cut. In 1925,<sup>1</sup> I reported a small series of cases and was then under the impression that the spermatic circulation could be sacrificed without serious atrophy. I now realize that this is not true. Bevan formerly sacrificed the spermatic circulation in 10 per cent of his cases. Then by more careful attention to the details of technique, he was able to reduce his percentage to 5 and more recently he has divided the spermatic vessels in only 3 per cent of his cases. It should be emphatically stated in this connection that Bevan does not encourage the indiscriminate division of the spermatic circulation. In fact, he decidedly warns against this procedure and permits it only in comparatively isolated circumstances. Ample mobility having been gained,

a pouch is prepared in the collapsed scrotum by blunt digital dissection. The testis is then placed in the newly formed scrotal cavity where it should be free from even light tension. The inguinal region is closed as in any ordinary hernial repair without transplanting the cord. The entrance to the scrotum is closed off with a subcutaneous purse-string suture.

That the principles of the operation as described by Bevan are not rightly interpreted by a good many surgeons is evident from the number of poor results. Operative failures are usually due to atrophy or retraction of the testis or both. Atrophy is due to interference with the circulation and trauma, and retraction usually follows insufficient mobilization and replacement under tension. It should be remembered that vascular structures are rather elastic and sufficient mobilization should thus be obtained to compensate for a certain amount of contracture after operation. Failure to take into account the elasticity and subsequent contracture of vascular structures is undoubtedly a large factor in poor late results.

Incidental anatomical facts that should be borne in mind when mobilizing an undescended testis whether in the inguinal or abdominal position, are first that the vas deferens nearly always has sufficient length for proper replacement of the testis in the scrotum and second that careful and diligent teasing out of the fibrous bands in the cord will usually permit complete mobility without sacrifice of essential structures even though at the moment the cord seems too short. A high ligation of the sac is necessary and in obstinate cases the last centimeter or two of mobility may be obtained by extraperitoneal stripping of the vas deferens and the component parts of the cord.

In reviewing the 32 cases, I was able to get follow-up data in but 15 cases, including 7 cases personally handled. An honest and faithful attempt was made to evaluate the end-results in view of the clinical data in the cases that were operated upon by other

surgeons. Accurate deductions are of course not always possible when reviewing the results of others but I submit the following data as reasonably correct.

TABLE I  
PREOPERATIVE DATA

	No. of Cases
Patients operated upon.....	32
Age at time of operation:	
2½ to 15 years.....	18
15 to 45 years.....	14
Right testis involved..	21
Left testis involved..	7
Both testes involved.....	4
Complications:	
Torsion of the cord requiring emergency operation.....	2
Strangulated hernia.....	2
History of strangulation.....	1
Evidence of malignancy.....	0
Nervous disorders.....	13
Bedwetting.....	1
Lowered mentality.....	3
Stigmata.....	3
Neuroses.....	8

TABLE II  
OPERATIVE DATA

	No. of Cases
Testis conserved.....	35
Testis removed (almost complete atrophy)..	1
Herniotomy performed.....	32
Evidence of malignancy.....	0
Position and condition of testis:	
(a) Inguinal position.....	28
Normal size (prepuberty).....	12
Normal size (postpuberty).....	4
Slight atrophy (prepuberty).....	5
Slight atrophy (postpuberty).....	3
Marked atrophy (prepuberty).....	1
Marked atrophy (postpuberty).....	3
(b) Intra-abdominal position.....	7
Slight atrophy (prepuberty).....	2
Marked atrophy (postpuberty).....	2
Normal size (postpuberty).....	3
Bevan operation performed:	
Without sacrifice of the spermatic circulation..	33
With sacrifice of the spermatic circulation....	3
Position at end of operation:	
Lower inguinal.....	7
High scrotal.....	7
Midserotal.....	16
Low serotal.....	6

TABLE III  
FOLLOW-UP DATA (15 CASES)

	No. of Cases
Evidences of recurrent hernia.....	0
Evidences of malignancy.....	0
Position of testis (4 months to 7½ years after operation):	

TABLE III (Continued)

	No. of Cases
Low serotal.....	6
Midserotal.....	2
High serotal.....	5
Lower inguinal.....	1*
Missing.....	1

Size of testis:

- (a) Atrophy following the Bevan operation with sacrifice of the spermatic circulation. (This was done in 3 cases)..... 3
- (b) No change or slight increase following the Bevan operation without sacrifice of the spermatic circulation..... 6
- (c) Marked increase following the Bevan operation without sacrifice of the spermatic circulation..... 1
- (d) Varying degrees of atrophy following the Bevan operation without sacrifice of the spermatic circulation..... 5

Neurotic manifestations generally relieved in all postpuberty cases.

\*This patient has since been operated upon (November 15, 1930) and by means of the Bevan operation, the right testis is now in a low serotal position and is of very satisfactory size and consistency. The patient is twelve years old, and from present indications the end-result will be satisfactory.

COMMENT

In a series of 32 cases of undescended testis, the greater frequency of right-sided involvement was noted. Undescended right-sided testis occurred three times as often as left sided undescend. Both testes were involved in approximately 6 per cent of the patients. Serious complications requiring emergency operation occurred four times (in the ratio of 1 to 8). Malignancy was not encountered. In only 1 case was the testis unmistakably a "total loss" and castration was thus performed only once. Herniotomy was carried out in approximately 91 per cent of the cases. The inguinal position was met four times as frequently as the intra-abdominal. Varying degrees of atrophy occurred three times more frequently in the inguinal testes than in those found in the abdominal position. Neurotic manifestations were common in postpuberty cases. Replacement in the scrotal cavity seemed for the most part to exert a generally helpful influence on the size and consistency of the testis. In 3 cases, there was no demon-

strable hernial sac. Obliteration of the neck of the vaginal process had evidently taken place normally. But in the vast

operator found the testis in an intra-abdominal position with the vas and its artery entirely separate from the cord



FIG. 4. Right ectopic testis with huge hydrocele of cord. Right scrotal cavity collapsed. (Three and half years after operation right testis occupies mid-serotal position.)

majority of our cases, some kind of hernial sac was present which is in keeping with the findings in other clinics. In no case did the presence of undescended testis prevent a satisfactory hernial repair and in none of the 15 cases followed, was there a recurrence of the inguinal hernia. Where entirely satisfactory end-results were not obtained, I believe that they can be attributed for the most part to failure to entirely comprehend the various steps in the operation and the failure to carry out the various refinements of technique as given to us in numerous contributions by Bevan.

It is interesting that in 1 case, the

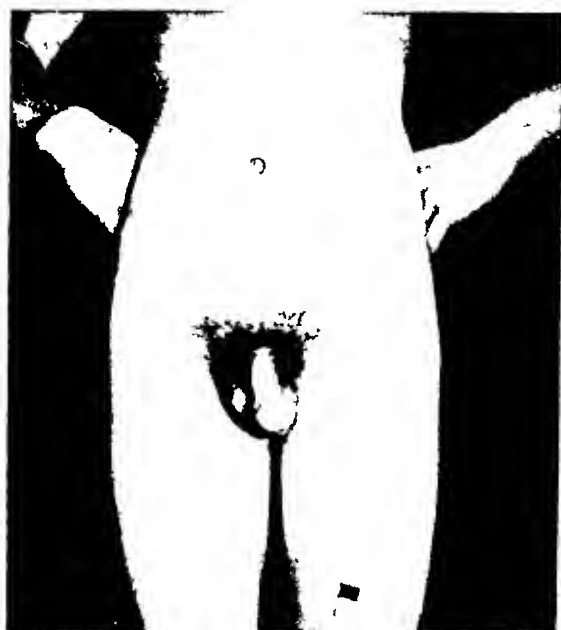


FIG. 5. Right inguinal hernia with testis in inguinal region at time of operation. Twenty-five months after operation right testis, though slightly atrophied occupies normal position.

structures and prolapsed downward into the inguinal canal. The general finding of a vas of normal length was however borne out in this instance.

In another case, the operator found to his surprise that the vas and not the spermatic artery with the accompanying veins was the "short" part of the cord. This was an interesting anomaly and naturally added to the difficulties of mobilization. In fact mobilization was quite unsatisfactory. I was not able to have a follow-up in this case. It is a generally accepted clinical notion that division of the vas deferens is followed by atrophy of the testis; yet some investigators including Alessandri of Rome claim that little if any atrophy follows division of the vas in experimental animals. If this fact should be borne out clinically, it might have been well for the operator in the case just cited to have boldly divided the vas and to have conserved the spermatic circulation which

was of sufficient length to obtain complete mobilization. The problem confronting the operator in an occasional very excep-

An Italian laborer who had an operation elsewhere for left inguinal hernia came to me for the relief of severe pain in his left



FIG. 6. Bilateral cryptorchid, aged twenty-eight. Marked secondary sex characteristics and very satisfactory sexual power. Testes in inguinal region. Absence of spermatogenesis by repeated laboratory tests. Collapsed scrotal cavities.

tional case may thus resolve itself into the following: If either the vas or the spermatic circulation must be sacrificed to gain sufficient mobility, would it be preferable to sacrifice the vas instead of the spermatic circulation? I have seen no references to the interesting and unusual finding of a short vas.

In 1 case, the operator, notwithstanding ample mobility of the cord and testis, found that he could not develop a scrotal pouch of sufficient size to replace the testis without tension. When the operation was completed, the testis occupied a high scrotal position. It has since retracted further. Possibly the Torek procedure would have been better in this case. (However, see note \* under Table 3.)

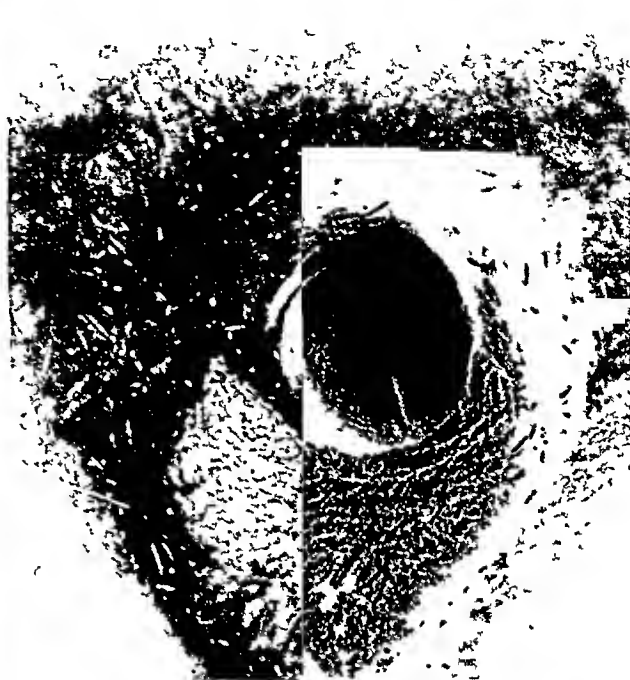


FIG. 7. Medical student aged twenty-two. Operation, March 21, 1924. Release of inguinally placed, slightly undersized right testis. Appearance, April 2, 1925. Testis normal in size and consistency and well down in reconstructed scrotal pouch.

groin. There was no visible evidence of a testis on his left side but the groin showed great scarring from infection complicating his previous operation. At operation, a badly scarred and atrophic testis was discovered in the inguinal region. I was able to bring the fibrotic and undersized testis to a midscrotal position where it has since undergone marked growth and development approximating the normal. I was about to sacrifice the testis as it seemed beyond redemption (Fig. 8).

#### SUMMARY

1. The etiology of undescended testis is obscure.
2. The tendency of the undescended testis to become malignant is overestimated. Furthermore, there is no evidence to show that an undescended testis that has been properly placed in the scrotum has any greater malignant potentialities than

the testis that has always had a normal position.

3. Undescended testis is, by virtue of the

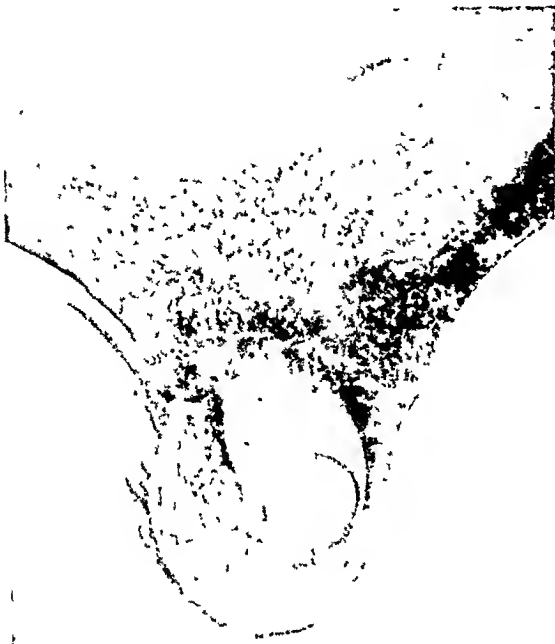


FIG. 8. Italian laborer aged thirty-seven. Previous unsuccessful operation elsewhere. Operation, Nov. 17, 1924. Release of badly scarred and markedly atrophic left testis from inguinal region. Appearance April 2, 1925. Testis in midscrotal position showed marked increase in size. Neurotic symptoms relieved.

anatomy involved practically always accompanied by a congenital hernia. This condition predisposes to serious life-endangering complications such as strangulated hernia and torsion of the cord. Early operation is thus advisable.

4. Careless and indiscriminate sacrifice of the undescended testis is not warranted since the vast majority of undescended testes, including those in the abdomen, can be brought down satisfactorily and therefore do not interfere either with the comfort of the patient or with a satisfactory hernial repair.

5. We have ample reason to believe that an undescended testis is by virtue of its position not necessarily irreparably damaged and doomed to dissolution and atrophy.

6. Undescended testes lose the power of spermatogenesis but continue to elaborate the internal secretion.

7. The scrotal position is necessary for complete anatomical and physiological development of the testis. Thus the sooner normal anatomical and physiological conditions are established, the sooner may we expect normal development.

8. Stigmata of degeneration, nervous disorders and neurotic states may accompany undescended testis.

9. Even the atrophic testis with questionable spermatogenesis should be conserved for the influence it may exert on the development of the secondary sex characteristics. The undescended testis should also be brought down for the stabilizing influence and moral effect that knowledge of its presence in the reconstructed scrotal cavity has on the patient.

10. Sacrifice of the spermatic circulation should not be made if mobilization is at all possible without division. Loss of the spermatic circulation invariably leads to high-grade and even complete atrophy.

11. By means of the Bevan operation, a satisfactory scrotal replacement of the testis is possible. When unsatisfactory results are obtained, we feel that they are generally due to failure on the part of the surgeon to faithfully and diligently carry out the Bevan principles in their minute details.

12. Finally, the problem of undescended testis will be solved only when a sufficient number of bilateral cases have been operated upon in boyhood and studied with regard to spermatogenesis and fertility before and after puberty. Surgeons should therefore follow their bilateral cases most carefully and report their late results.

#### DISCUSSION

DR. I. E. SIRIS: In view of the experiences and observations at Bellevue Hospital and in the light of Dr. Meyer's results, they had generally abandoned the Bevan operation in favor of the Torek procedure. He believed that after the Bevan operation there were too many instances of retraction and stressed the point that the Torek operation prevented retraction and insured a permanent normal anatomical position of the testis. The secondary



minor operation which is required after the Torek operation consists merely of a slight plastic to release the fixated testis and repair the small scrotal defect.

DR. R. F. BARBER: The general notion of aspermatogenesis in the bilateral cryptorchid was by no means always borne out clinically and he cited a specific instance to illustrate. A bilateral cryptorchid had been responsible for a number of impregnations though he had been popularly regarded as lacking in spermatogenic function. Certain receptive and trusting ladies had to their sorrow been able to vouch for his powers.

DR. ARTHUR GOETSCH: With reference to the Torek operation: it will be recalled that the tables showed a number of cases that were followed and in which the eventual position of the testis was either too high in the scrotum or low in the groin. There was 1 case in which the operator noted that his efforts were seriously compromised by a very small and resistant scrotal cavity. He obtained fair mobility, but could not replace the testicle without tension. I have had no experience with the Torek operation, nor have the other men at the Hospital, as far as I know, but in this particular case, after studying the Torek procedure and reading Dr. Meyer's reports, I believe the patient might have been given the benefits of the Torek operation. (However, see note \* under Table III.)

As to the consideration of whether the heat regulating mechanism of the scrotum, viz., the dartos muscle and the cremaster which are necessary for elevation and relaxation of the testicle, according to whether the surrounding

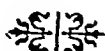
environment is warm or cold, is conserved by the Torek operation, I fear that perhaps the dartos reflex would not be preserved. These points, however, are merely theoretical considerations, which perhaps Dr. Siris might be able to clear up. I believe something more might possibly be done for that type of case, no matter how firmly we may be convinced of the advisability of the Bevan operation in general.

The literature is sadly lacking in the matter of sufficient study of the question of spermatogenesis; while it is well to talk about the single undescended testicle, it must be remembered that there is a testicle on the opposite side which may be taking care of the normal physiological functions.

In regard to the question of secondary sex characteristics I find that certain people believe that possibly the cells of Leydig may not have as much to do with this problem as is generally supposed. It has been suggested that the Sertoli cells are the important if not actually the chief ones concerned in developing secondary sex characteristics. There is a little evidence tending to show that this may be the case, because after almost complete loss of spermatogenesis, from an histological standpoint, the Sertoli cells are frequently present in very fair abundance. Thus if their sole function were to sustain the spermatogonia, it is reasonable to suppose that when the spermatogenic tubules disappear, the Sertoli cells would disappear with them. Their stubborn resistance against dissolution however suggests an added function, possibly in developing secondary sex characteristics.

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# PRIMARY FIBROMYXOCHONDROSARCOMA OF ENDOMETRIAL STROMA\*

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**A**LTHOUGH fibromyxochondrosarcoma (osteogenic sarcoma) is not an uncommon neoplasm of bone and



FIG. 1. Fibromyxochondrosarcoma situated on posterior endometrial wall. It presents a cauliflower-like appearance similar to a papillary adenocarcinoma.

cartilage, its presence as a primary growth in the endometrial stroma is so rare that it borders on the unique. The following is the report of such a case recently observed by us.

A colored woman, aged thirty-six years, came to The Mayo Clinic May 6, 1930, complaining of menorrhagia and leucorrhea of eighteen months' duration. She had been married twice, and had had two children, both alive and well, and two miscarriages by her first marriage; pregnancy had not occurred after the second marriage. The menses began at the age of eleven years, were regular and somewhat painful. In 1927, laparotomy had been performed elsewhere for a pelvic abscess, after which there had been a gradual onset of frequency of urination, burning, general malaise and fever, pelvic pain, vaginal discharge, menorrhagia and metrorrhagia over a period of three months. She improved after the operation although there was considerable drainage for four months. Six months before she came to the clinic dilatation and curettage were done on

account of slight menorrhagia, leucorrhea and metrorrhagia. Although she was much better after this, she still complained of leucorrhea and frequency of urination. A few months before admission the leucorrhea became worse and was blood-stained; accompanying this were periods of profuse menstrual bleeding lasting five days. There were also cramping pelvic pains with the passage of clots. Menstrual periods were regular.

On general examination the blood pressure, pulse and temperature were found to be normal. A catheterized specimen of urine showed pus, graded 1 (8 cells). Erythrocytes and leucocytes were normal. The hemoglobin was 66 per cent (11.1 gm.). Roentgenograms of the thorax and pelvis were negative. Teeth and tonsils were infected. There was an abdominal hernia at the site of the laparotomy scar. The uterus was enlarged to three times normal size and was irregular in outline. The cervix was enlarged and contained a cauliflower-like ulcerating bleeding mass with several small nodules around it. A preoperative diagnosis was made of fibromyomas of the uterus, pelvic inflammatory disease and post-operative hernia.

May 9, total abdominal hysterectomy was done, with bilateral salpingo-oophorectomy, appendectomy and repair of the abdominal hernia. The patient's convalescence was uneventful.

On examination of the tissue removed at operation bilateral chronic salpingitis and perisalpingitis, and bilateral chronic cystic oophoritis and perioophoritis were found and both tubes were firmly adhered to the ovaries. The largest cyst in the right ovary was 1.5 cm. in diameter; the largest cyst in the left ovary was 2 cm. in diameter. In the edge of the right ovary was a fibromyoma 1.5 cm. in diameter. The appendix was chronically inflamed. There were multiple small fibromyomas of the myometrium. On the posterior endometrial wall, projecting into the cavity, was a soft, gelatinous, cartilaginous, cauliflower-like growth, 8 by 7 by 3.5 cm. (Fig. 1). The tumor had infiltrated the myometrium to a slight degree. This

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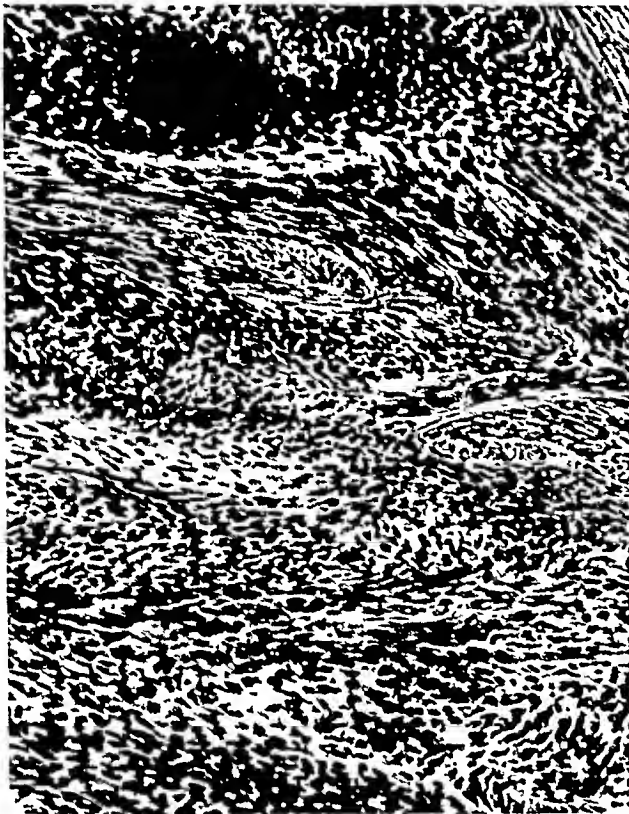


FIG. 2. Fibromyxochondrosarcoma, graded 2, of endometrial stroma, showing invasion of myometrium by round, oval, spindle, and stellate cells.

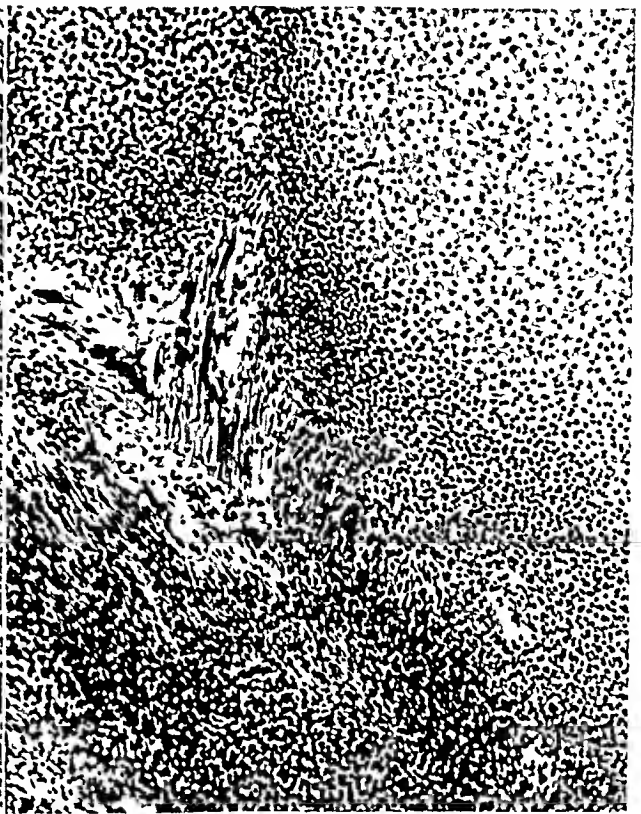


FIG. 3. An area in which part of the cells retain the form of those presented in Fig. 2 and others are differentiating into cartilage.

tumor presented a diverse histologic picture. The cells situated between the endometrial glands and in the musculature were round, oval, spindle, and stellate (Fig. 2). They appeared to be differentiating into fibrous and myxomatous tissue. Mitotic figures were not infrequently seen. Other areas showed that the tumor was retaining to some extent the cellular structure described, but at the same time part of the cells were differentiating into cartilage (Fig. 3); other areas showed pure cartilage, free from mitosis, and presented the picture of a benign chondroma (Fig. 4). A diagnosis was made of fibromyxochondrosarcoma, graded 2.

It is only natural, in commenting on the case, to ask how the presence of a cartilaginous tumor in an organ where cartilage is not normally found can be accounted for. Some will say it was due to the presence of an embryonic rest. This probably is not true. It is well known that fibrous connective tissue, mucous tissue, and cartilage are closely related; therefore, it is easy to see how the undifferentiated cells of such tissues could differentiate into any of them.

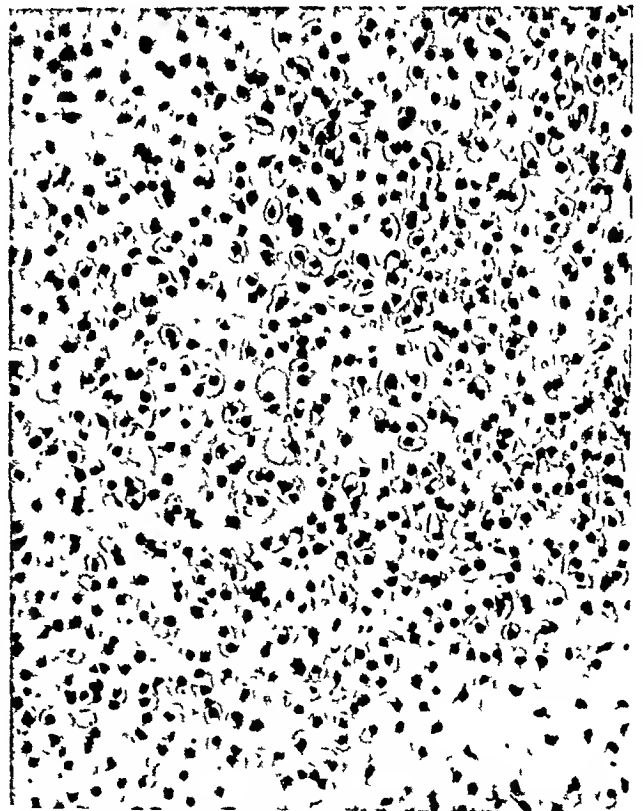


FIG. 4. Area showing well differentiated cartilage, free from mitosis and presenting a picture like that seen in benign chondroma.

# SEPTICOPYEMIA

DUE TO STAPHYLOCOCCUS HEMOLYTICUS\*

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**N** W., aged forty-five years. American, laborer, married, entered the hospital February 22, 1930, complaining of pulmonary symptoms that were diagnosed as bronchopneumonia. His past history was negative except for a herniotomy in 1916 and influenza in 1927. His wife had been married previously to a man who had died from tertiary syphilis. She had been intensively treated before her second marriage and three Wassermann tests were found to be negative.

During the next three weeks, a number of hypodermatic injections were given in the region of the deltoid insertion in each arm. His progress was uneventful and at the end of the third week, he was sitting out of bed preparatory to going home. On March 10, he had a severe chill followed by temperature of 106°F., pulse rate 120. These chills recurred two or three times daily during the next week; the temperature varied from 101° to 105°F., followed by drenching sweats. Examination disclosed an abscess of each arm at the site of the previous hypodermatic injections. These were immediately incised and drained but the symptoms did not subside.

## Laboratory Findings:

Blood: Hemoglobin, 60 per cent.

Erythrocytes, 3,050,000.

Leucocytes, 20,750.

Polynuclear neutrophile, 90 per cent.

Lymphocytes, 10 per cent.

Appearance of erythrocytes, very distorted.

Blood sugar, 96 mg. per 100 c.c.

Non-protein nitrogen, 38 mg. per 100 c.c.

Urea, 17.9 mg. per 100 c.c.

Spinal fluid: Negative.

Wassermann test: 2 plus.

**Blood Culture:** Positive for staphylococcus hemolyticus on March 15, 31, and April 9. On May 5, no growth after forty-eight hours.

**Urinalysis:** Specific gravity, 1.020.

Albumin, trace.

Indican, 4 plus.

Cast, hyaline and granular.

Many blood cells.

Occasional pus cells.

**Blood Pressure:** 140/86.

During the next three weeks, there developed multiple abscesses throughout the body, on palmar surface of both hands, dorsal surface of right wrist, over right hip-joint and buttocks and over external malleolus of right leg. These were incised and drained. Myositis, with extensive suppuration and sloughing of necrotic tissue, provided a baffling problem early in the case. Daily injections of mereurochrome No. 220, 1 per cent, 15 c.c., were given intravenously. Repeated blood cultures revealed a decrease in number of staphylococci present and the general symptoms abated. Because of the severe secondary anemia, a blood transfusion of 500 c.c. was given during the first week following the infection. Two more transfusions were given during the next ten days.

Following the intravenous injections and blood transfusions, there was an apparent improvement which lasted only a few days, and was followed by more abscesses, chills, and high temperature. In addition there suddenly developed a severe panophthalmitis of the left eye, apparently due to infected embolus. After consultation with an ophthalmologist, it was decided to eviscerate the eye under local anesthesia. This was done the following day and a large amount of pus evacuated.

In the meantime, neosalvarsan was given intravenously and mercury by inunction, as it was thought that probably lues had something to do with the patient's lack of resistance. Glucose, 5 per cent, 2000 c.c. daily, was given to supply the necessary fluids and prevent dehydration. Blood culture of April 9 was positive for staphylococci but on May 5 the culture was negative after forty-eight hours' incubation.

On April 9 another blood transfusion of 500 c.c. was given, resulting in general improvement. The wounds, for the first time, showed a tendency to heal, temperature subsiding to 99°F., the pulse varying from 92 to 100. May 1,

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symptoms of pulmonary complications appeared. Previous to this time, repeated x-rays revealed no signs of lung involvement. May 2 after careful examination, it was decided that there was a probable lung abscess or localized empyema present. Thoracentesis in left mid-scapular line revealed thick creamy pus which contained long chain streptococci. Drainage by closed method was instituted and during the next twenty-four hours, over 500 c.c. of pus were evacuated. During the next few days, patient was irrational at intervals and complained of considerable pain over right iliac region radiating down femoral canal. Ulceration and sloughing of tissue over right hip-joint until the joint itself was eroded. Pulse became increasingly rapid rising to 140, temperature varying from 100°F. to 101°F. There was no marked abdominal distention or tympanites, though involuntary micturition and defecation occurred during last few days of illness. Patient gradually sank into a coma and died on May 22, 1930, nine weeks after the beginning of the blood stream infection.

The following is the *autopsy report*: General: Male, poorly nourished, left eye enucleated, wound completely healed, no infection or inflammation present. Right eye, pupil enlarged. There are two ulcers in sacral region, one 3 in. long, 1½ in. wide, the other 5 in. long, 2½ in. wide, skin absent, the spine is exposed and covered with a suppurative membrane. On right hip a circular lesion, 2 in. in diameter, covered with coagulated blood (hematoma). On right knee a circular ulcer 1 in. in diameter, on right ankle a small dried ulcer. On left hip the bone is exposed, a skin defect ca. 2½ in. by 2 in. The right leg in semiflexion, femur rotated outwards, sole of feet inverted.

Chest: When an incision is made into the diaphragm pus empties from abdominal cavity under high pressure. In the pericardial cavity 1 oz. of a reddish serous fluid present.

Heart: Flabby, dilated, no coagulated blood in ventricles. There is a thrombus present in the pulmonary artery adherent to the wall, attached to trabeculae carneae of right ventricle. Mitral and aortic valves tendinae, normal.

Lungs: Left, upper lobe adherent on dorsal surface, slightly congested on cut section. Lower lobe adherent to dorsal wall of mediastinum, covered with a fibrinous membrane on the lower half of dorsal aspect. On cut section there is red hepatization.

Right, not adherent, moderate congestion.

Abdominal Cavity: Filled with thick pus, which forms a fibrous membrane on the surface of intestines.

Liver: 2000 gm. in weight, grayish color on surface. On cut section, normal.

Spleen: There is an opening in the skin of the back which with a probe can be followed to the upper third of the spleen. This third of the spleen shows a dark red, almost black friable mass (hemorrhage). The lower two-thirds of the spleen are enlarged, very friable and soft.

Kidneys: Left, enlarged, capsule strips easily, ecchymoses present on cut surface, parenchymatous degeneration.

Right, capsule adherent, kidney enlarged, tissue very soft, ecchymoses on cut surface.

Genitalia: Normal.

Mesentery: Inflamed.

Right Iliac Region: Filled with thick pus. The muscular tissue is necrotic, the head of the femur is exposed, partly necrotic, the joint completely destroyed. The pus of the abscess had travelled down the femoral canal. It cannot be followed upwards to the vertebrae.

Diagnosis: Diffuse peritonitis, hemorrhage of spleen, iliac abscess, multiple abscesses on back and hips, beginning hypostatic pneumonia, degeneration of heart muscle, parenchymatous nephritis.

Cause of Death: Multiple abscesses, diffuse peritonitis, septicemia. No tissue sectioned.

A voluminous literature has been devoted to streptococcus septicemia, but blood stream infection by the staphylococcus seems to have received much less attention. Most writers agree that these cases are uncommon in occurrence and extremely serious. Phemister<sup>1</sup> states that staphylococci not infrequently enter the blood from skin foci with consequent inflammation of various structures throughout the body. Among the foci, he lists boils, carbuncles, acne pustules, impetigo, vaccination wounds, excoriations, blisters, etc. He believes that certain strains, regardless of virulence or portal of entry, possess the power of attacking certain tissues. Lesions of the nose and accessory sinuses are probably an important source of infection, while the tonsils and teeth are considered as doubtful causes.

Russum<sup>2</sup> emphasizes the fact that sta-

phyllococcic septicemia is prone to follow even trivial focal infections such as a scratch of the skin, and the prognosis is very grave. He has devoted much attention to the pathology and has outlined it in a comprehensive manner. An infection, such as occurs in furunculosis and impetigo, may be followed by the breaking off of thrombi which lodge in various systems of the body resulting in pyemia. As a consequence there may result:

First: In the lungs, atypical bronchopneumonia or edema.

Second: Generalized adenitis; acute splenic tumor, secondary anemia, leucocytosis.

Third: Heart; endocarditis, cloudy, swelling, abscesses, myocarditis.

Fourth: Gastrointestinal; submucosal petechial hemorrhages.

Fifth: Kidney; suppurative nephritis.

Sixth: Osteomyelitis.

Seventh: Cerebral abscess.

His experience leads him to believe that the mortality is about 70 per cent, especially after furunculosis.

A careful examination of the literature available on this subject does not disclose many cases directly attributable to infection following hyperdermatic injections. The case cited in this paper was a direct result of such infection, despite the fact that he was under the care of a special nurse in a hospital of good standing. Undoubtedly careful investigation will disclose other cases due to the same cause.

An interesting feature was the striking temporary improvement following the intravenous use of mercurochrome. Despite the extreme gravity of the situation, the first few injections of the dye caused a subsidence of the symptoms and a marked decrease of the staphylococci in the culture until May 5 when the culture showed no growth.

Piper<sup>3</sup> reports a number of cases of staphylococcus septicemia, including one of meningitis, with final recovery of the patients. Fox of the University of Pennsylvania states that before the use of mercuro-

chrome he had seen no case of staphylococcus septicemia recover. Young<sup>4</sup> reports 7 cases cured by mercurochrome and 5 by gentian violet. Attention has been called to the incidence of staphylococcus septicemia secondary to mastoiditis and sigmoid sinus thrombosis by Harold Lille and Joseph Stevens<sup>5</sup> in an interesting case report.

Gatch, Trussler and Owens<sup>6</sup> believe that a certain number of cases will recover without any special treatment and that too much reliance should not be placed in the use of dye solutions. They state that with the use of gentian violet and mercurochrome, 40 per cent of the cases will improve, 40 per cent will remain unimproved and 20 per cent can be classed as doubtful. On the other hand, Churchman<sup>7</sup> says that even if there are 30 per cent failures in using anti-meningococcic serum, yet it should not be discarded in the treatment of meningitis, neither should some failures discourage the use of dye chemotherapy.

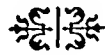
There seems to be a unanimity of opinion that regardless of other treatment, final recovery depends upon finding and draining of every important suppurating area. Myositis and iliopsoas abscesses are frequent complications in staphylococcus septicemia and may prove the deciding prognostic factors. The unsuspected splenic abscess, which probably perforated into the pleural cavity, together with the iliopsoas abscess causing diffuse peritonitis, were undoubtedly the factors that rendered this case hopeless. The blood cultures were negative for seventeen days before death.

Russum, Young, Piper, Churchman and others, believe that chemotherapy gives promise of decreasing the high mortality from this type of septicemia. Churchman states that dyes such as gentian violet, are carried by the blood stream to certain organs of the body, in which they remain in concentration for some period of time. It is because of this that they have an excellent chance for exerting bacteriostatic effect.

If it is true as Phemister has stated in his excellent review of this subject, that 90 per cent of hematogenous osteomyelitis is due to staphylococcus infections entering through the skin, even if there were no other complications, this subject would merit serious attention and further investigation. The utmost precaution should be used in hypodermatic medication which is increasing in popularity and use. Meticulous care should be used in any surgical procedure, however slight it may be, involving the skin, always remembering it is the normal habitat of the staphylococcus and presents an inviting portal of entry.

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\* Continued from p. 57.



# THE DIAGNOSIS AND TREATMENT OF ACUTE OSTEOMYELITIS OF THE HEAD AND NECK OF THE FEMUR\*

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**I**NTRODUCTION. This paper will be on the early diagnosis of acute inflammation of the head and neck of the femur and will not consider cases which have progressed to the stage of inflammation which has spread through the cortex of the bone.

When the diagnosis has been delayed, the results of any method of treatment are very unsatisfactory. This paper is written to emphasize the importance of early diagnosis and to show how simple the disease is when diagnosed early and treated properly.

## ANATOMY OF THE UPPER END OF THE FEMUR

The anatomy of the femoral neck, before complete ossification has occurred, has some bearing upon the method of treatment proposed in this paper. As practically all the patients suffering from acute osteomyelitis of the femoral neck are children the question of ossification must be kept in mind. Long bones increase in length by deposition of bone at the junction of the epiphysis and diaphysis, i.e., the metaphysis. Any disturbance of this area by inflammation or by operation may seriously affect the length of the bones as the patient grows older.

There are three centers of ossification at the upper end of the femur, i.e., one in the head which appears during the first year, one in the greater trochanter which appears in the second year and one in the lesser trochanter which does not appear until the twelfth year; all of these centers of ossification fuse between the eighteenth and twentieth years. Owing to the location of these centers, only one, i.e., that in the head, would be of any serious importance. I am unable to find any reliable information as to how much shortening of the femur might occur if damage were done

to the growth line of the upper end of the femur in early life. The patients whom I have treated or examined after they were well, who had suffered damage to the femoral neck, have had shortening due to loss of bone, deformity, etc., and, therefore, the extent of the shortening due to destruction of the line of bone growth, if any, could not be accurately determined. The shortening seemed to be due to destruction of the femoral neck.

It has occurred to me that there is a possibility of serious injury to the metaphysis or growth line by the use of the drill. However, it does not do the injury that inflammation can and does always do if not relieved. While this danger should be recognized, it should not deter the operation.

In no instance do the centers of ossification in the trochanter come into consideration as no surgeon would interfere with them.

## ETIOLOGY AND PATHOLOGY

This description will be very brief as the diagnosis and treatment are the features of this paper.

The disease begins in the femoral head and neck in the cancellous bone as there is no true medulla as elsewhere in long bones. The infection is blood-borne and the pathogenic organisms lodge in the small arteries as septic bacterial emboli; the actions of these germs of which there are several well-known varieties, but usually some form of the staphylococcus, cause bone necrosis and death. Stagnation of the circulation and necrosis of the tissues occur because of the unyielding bone which prevents swelling of the tissues and septic absorption into the blood stream rapidly occurs; it is these conditions which produce such serious general symptoms and such

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severe local manifestations. If the infecting organism is of a mild type such as the pneumococcus or the patient's resistance is high the pathological process may be arrested before necrosis occurs. In such cases the symptoms are mild and the infection soon subsides.

In the fulminating types, the streptococcus is usually the infecting agent and the local disease is probably a manifestation of a general blood stream sepsis. As this paper is based upon early cases no further discussion of the pathology and its extensions to the joint or in a more extensive region of the bone will be discussed.

#### SYMPTOMS OF ACUTE OSTEOMYELITIS OF THE FEMORAL HEAD AND NECK

The general constitutional symptoms are the same as for the various types of any inflammation, but they vary greatly in their manifestations and intensity. The more acute the infection, the more debilitated state of the patient, the greater extension of the pathological process and the virulence of the infecting organism determine, to a large extent, the symptomatology.

Among the general symptoms may be mentioned fever, localized pain, tenderness, disturbed function of the joint and, in the later stages, swelling and edema. There are three well observed types of acute inflammation of the neck of the femur, viz.:

1. *The Subacute Type.* This is due to the low virulence of the infecting organism, such as the staphylococi, usually the albus, the pneumococcus and in rare instances the colon bacillus. Also, the physical condition of the patient often assumes great importance. For instance, in infection of the neck of the femur associated with or following any acute general infection such as measles, scarlet fever or pneumonia, especially in children, the local symptoms may be easily overlooked. In such instances, the involvement of the femoral neck may be far advanced before it is discovered.

Then, too, even in otherwise healthy

children, the onset may be so insidious and the local symptoms so indefinite that its real nature may be obscured. In such patients, there may be few if any early local symptoms and the fever, rapid pulse and general bodily discomfort may be ascribed to some acute infection. Even in such cases, however, an examination of the affected joint will disclose tenderness on deep pressure, some limitation of movement of the joint and a tendency to protect the joint by holding it in a flexed and slightly abducted position. I have observed this form of the disease as a sequel of some acute systemic infection in nearly all instances.

2. *The Acute Type.* In this type, traumatism is supposed to play a prominent rôle. I have not found it so. As this type, like all other forms of the disease, occurs nearly always in growing bones, i.e., in children who are subject to all forms of mild injuries many times every day in the life of the ordinary young person, too much emphasis is often assigned to some local injury; if trauma were a factor of any real importance, could any normal child escape? Then, too, if injury to bone were a causative factor, the bones most subject to osteomyelitis would naturally be the ones most often the seat of the disease, but such is certainly not the case. For instance, the knees, i.e., patella, the shin bone, the olecranon, the skull, etc., would be uniformly involved. Then, again, the seats of infection are in the ends of the diaphysis which are deeply situated and covered with muscles, other soft tissues and the hard, resistant cortex serve as a protection to these regions where infections always occur.

The symptoms of the acute type are general and local, the child generally complains first of feeling ill for a short time, i.e., a few hours to a day or so, before the onset of pain. Fever nearly always precedes the pain. The pain is at first mild, but rapidly becomes severe; it is a deep boring, constant aching near the joint, but not in the joint, and limited to a well defined area on one side of the joint and not wholly



around the joint as in any acute arthritis. The symptoms of a general infection are present such as rapid pulse, nausea, vomiting, occasionally rigors or chilly sensations and frequently mild mental disturbances. But pain in the region of the end of the bone is the predominant and most characteristic symptom. The child lies with the affected thigh flexed and resents any movement. In early cases there is no swelling. Tenderness is at first deep and not marked; it is in front and along the line of the femoral neck, but occasionally it is posterior. Unless the head is inflamed, movements of the joint are not particularly painful.

3. *The Fulminating Type.* In this form, the general constitutional symptoms almost completely overshadow the local. The toxemia is great, the pulse is rapid, the temperature high, delirium marked so that often the pain is not complained of or even noticed. In this form, the appearance of swelling and edema around the affected joint are often the first signs to call attention to the location of the real trouble. Then, it is too late for an early operation. The local infection of the femoral neck is only a part of a generalized blood stream infection. The white blood cell count is usually very high with a high differential percentage. The urine is not different from that of any other acute infection.

#### THE DIAGNOSIS OF ACUTE OSTEOMYELITIS OF THE FEMORAL NECK

The diagnosis to be of any real value must be made very early in the course of the disease. Otherwise, destructive processes will occur which will inevitably progress to destruction of bone and probably the joint; this will cause prolonged invalidism, life-long deformity or in the worst cases death of the patient.

This study is based upon 12 acute cases, 10 of which were children and 2 were adults. In 10 the diagnosis was made before the inflammation had spread through the cortex. The other 2 were far advanced, 1 was first seen by me on the twelfth day and the other on the fourteenth day.

The symptoms of diagnostic importance were as follows:

1. Fever of varying degree from 101 to 105 F.
2. Rapid pulse out of proportion to the height of the fever, i.e., from 120 to 160 per minute.
3. Mental disturbance from a mild psychosis to a wild delirium.
4. High white blood cell counts with very high differential polynuclear cell percentage.
5. Limitation of movement of the affected hip. This may be only very slight or it may be pronounced even to complete fixation of the joint.
6. Local swelling due to spreading inflammation or edema. This may be scarcely noticeable or be fairly marked.
7. Tenderness of varying degree is always present, but in the mild forms of the disease it may be very slight.
8. Chilly sensations or rigors are often noticed.

9. Pain is always present, except in the fulminating types when the sensorium is so benumbed that the patient is incapable of noticing anything. Pain and tenderness generally are located very accurately at the focus of infection, especially in the early cases. When the focus of infection is in the head of the femur, pain and tenderness are generally more acute and more definitely localized; limitation of motion is definitely greater than when the area of infection is confined to the femoral neck. The child is usually very restless, cries out without any apparent reason, moves the arms, body and the healthy leg freely but holds the inflamed joint flexed and immovable.

The only disease of the joint of similar symptomatology which might be confused with acute osteomyelitis is acute arthritis either rheumatic or infectious; these are so rare that I have never seen a case confined to the hip. When these are to be considered the differential points are not very clear. Acute articular rheumatism in a child involves other joints as a rule and is not so acute and is often preceded

by acute tonsillitis and is associated with heart complications such as valvular sounds, sour sweats, and previous debility, etc. The child who develops acute osteomyelitis generally gives a history of previous good health.

A word further as to value of a history of traumatism. In none of my patients was there such a history which could be remotely connected with the onset of the disease.

The diagnosis should be made within twenty-four to forty-eight hours after the onset of pain; operation should follow without delay.

#### EXAMINATION

The patient should be examined with great gentleness as the least roughness may set up defensive reactions and the most informing part of the examination defeated. Palpation of the joint both anterior and posterior as well as percussion or pressure on the great trochanter and thigh should be carefully and methodically done in all instances. There is always a tender area generally in front along the line of the neck or directly behind in the opposite region. Percussion on the great trochanter causes pain, especially if the head is involved. Movements of the affected leg will, also, detect tenderness or muscle spasm which is often an observation of value. In the patients suffering from the milder forms of the disease the local signs and symptoms are slight during the early stages.

One is justified in making the diagnosis of acute osteomyelitis if there are local tenderness, limitation of motion, etc., associated with local pain and the usual symptoms of a general infection; the diagnosis is more certain if the cause cannot be found elsewhere or in some obvious injury to the joint.

The x-ray is useless in the early stages of the disease, but should always be made if there should be a history of trauma; also, it is necessary for showing an accurate line of the femoral neck when operation is

performed. When the x-ray is of diagnostic value, the early stage has passed and a long, tedious course of invalidism, multiple

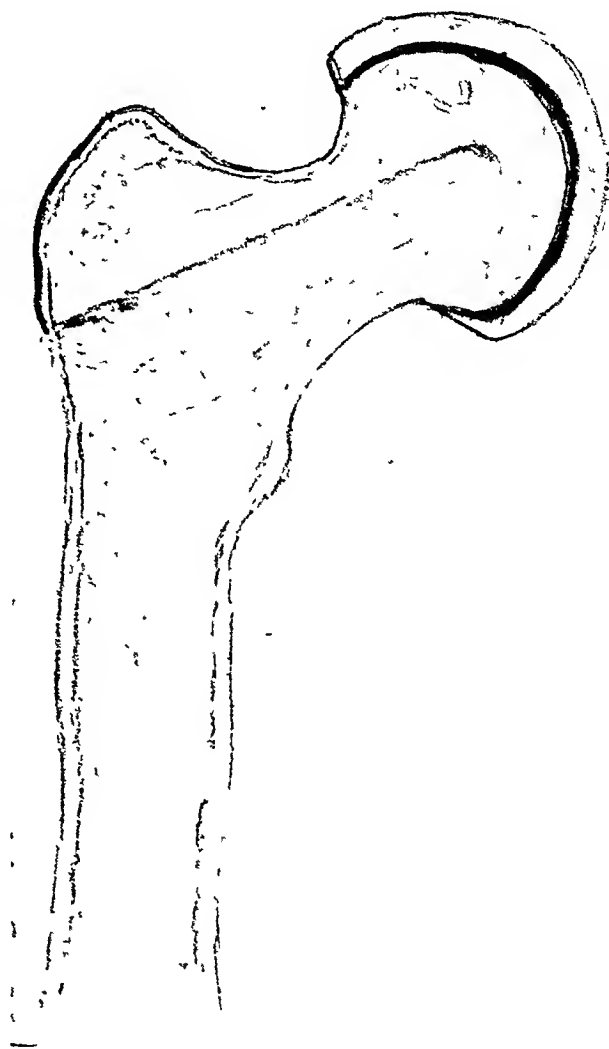


FIG. 1. Operation showing usual site of drill hole.

operations and a more or less chronic septic state lie ahead for the unfortunate patient.

#### THE OPERATION OF CHOICE

The operation which I propose is an old, but little used procedure. The first mention is by Macnamara of Dublin; the operation which he proposed and performed was very simple and easily done. It was carried out by exposing the great trochanter through a vertical incision, centered just below the base of the great trochanter exposing the bone quite well. Then, a fairly large drill hole was made up through the shaft to the upper end of

the neck and then if needed, to the head of the femur. A simple drain was used.

The success of the operation depends upon the accuracy of the drill hole passing up the center of the neck as it is quite easy to miss this region and for the drill to pass out of the neck into the surrounding tissues and thus miss the focus of infection, which would of course vitiate the operation. If pus does not well out, as it always does when the inflammatory focus is penetrated by the drill, the direction of the bit should be changed and another hole made. X-ray photographs serve as reliable guides to the line of the neck and should always be taken prior to the operation. There is no shock to the operation and the small wound soon heals after the drain is removed.

The one question which is of the greatest importance is the danger which might be done to young, growing bone centers which might result in later shortening of the upper end of the femur. The results of the operation are, in early cases, so uniformly good that this danger is largely hypothetical, and may be ignored, especially when compared to the disastrous results through the loss of bone in delayed cases.

#### CASE REPORTS

In the series for this paper there are 12 patients. Two were adults. One adult was in the hospital suffering from a chronic recurrent osteomyelitis of the ischium with an acute abscess when he developed a typical case of acute infection of the femoral neck. The operation was carried out within forty-eight hours with immediate relief of the acute symptoms and stoppage of drainage within ten days. The other was sick about two weeks. The operation was performed and much pus evacuated but the bone destruction was so great that there was a long convalescence and deformity.

The next 10 cases were in children. Nine of these were operated on early with complete relief before serious bone destruction. The stay in the hospital was from ten to twenty-two days. There has

been no case of deformity or serious shortening in these patients. One patient was operated on the fourteenth day; the results were very disappointing.

#### SUMMARY

1. Acute osteomyelitis of the head and neck of the femur is an acute infection of the bone, limited in the early stages to a small focus.
2. The symptoms of early infection are definite and characteristic and should lead to a correct diagnosis.
3. Operation, preferably through the neck to the site if infection followed by drainage usually leads to immediate recovery without the spreading of the infection to the adjacent bone.
4. Operation after the infection has spread to the cortex and to the soft tissues usually does not stop the spread of the inflammation or prevent destruction of the bone and the joint with subsequent long invalidism and great deformity.
5. Twelve cases are reported with 10 early operations which were successful and 2 late cases which were failures.

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# A CLINICAL AND LABORATORY STUDY OF THE THERAPEUTIC VALUE OF LACTOBACILLUS ACIDOPHILUS\*

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IN the rather extensive literature concerning the therapeutic value of the bacterium *Lactobacillus acidophilus*, there is a noticeable lack of information upon which judgment can be based as to the efficacy of this organism in the treatment of the various gastrointestinal disorders for which it has commonly been recommended. Obviously, if such information is to be of value it must include adequate clinical and bacteriological findings. We have both had considerable experience in the therapeutic use of *Lactobacillus acidophilus* for a number of years. In the past two years we have made a combined study of several of the numerous preparations purporting to contain viable *Lactobacillus acidophilus* organisms in sufficient numbers to have a therapeutic effect. We have studied the clinical results obtained when these preparations were administered to patients suffering from amenable ailments and we have attempted to correlate the bacteriological findings of the stools with the progress of the clinical picture.

The value of *Lactobacillus acidophilus* as a therapeutic agent is its peculiar ability not only to resist the environmental hazards of the intestinal tract, but to establish itself and to actually proliferate in that environment when ingested in sufficient numbers and with regularity. It is, then, the attainment of such an aciduric flora which is sought for in the administration of any preparation containing this organism. Therein lies its claim to recognition as a therapeutic agent in amenable gastrointestinal disorders. The value of an aciduric type of fecal flora has long been recognized and several methods have been employed to effect its establishment. For example,

kaolin has been found advantageous in the treatment of certain specific intestinal infections and intoxications and its administration to laboratory animals and man has been shown to result in the transformation of the fecal flora from one predominantly gram negative in type to one predominantly gram positive or aciduric. Much has been reported concerning the ability of lactose, dextrine, large quantities of milk and of diets containing considerable quantities of these products in fostering an aciduric fecal flora in man. Their ability in this connection has been established.

Rettger and Cheplin first called attention to the implantability of *Lactobacillus acidophilus* and ascribed to it a therapeutic value in the correction of disorders attendant upon a non-aciduric type of intestinal flora. Further, they convincingly demonstrated the non-implantability of *Lactobacillus bulgaricus*, which was proposed by Metchnikoff to combat an undesirable intestinal flora.

The characteristics of the bacterium *Lactobacillus acidophilus* have not been well defined. It was first described by Moro in 1900 and later in the same year by Finkelstein and Tissier. Rahe separated it from the morphologically and culturally similar *Lactobacillus bulgaricus* on its inability to ferment maltose and designated four groups of *Lactobacillus acidophilus* on a basis of sugar fermentations. Albus and Holm found that when sodium ricinoleate was added to a suitable medium in sufficient amount to depress the surface tension of the medium to 40 dynes or less, that the growth of *Lactobacillus bulgaricus* was inhibited while *Lactobacillus acidophilus* grew vigorously. Their work was later confirmed by Kopoloff.

\* Read at the Thirty-third Annual Meeting of the American Gastro-Enterological Association, Atlantic City, May 5 and 6, 1930.

Numerous attempts to identify a type organism on a basis of acid production have shown the existence of a wide variation in the quantity of acid produced by the different strains. Colony formation studies have revealed so-called "x" and "y" types of *Lactobacillus acidophilus*. The acceptance of the implantability of *Lactobacillus acidophilus* and the non-implantability of *Lactobacillus bulgaricus* is a characteristic of certain value which, if the suggestion of Albus and Holm might prove correct, might be culturally established. They suggest from their work that the nonimplantability of *Lactobacillus bulgaricus* is due to its inability to grow in a medium of low surface tension. Larson has investigated the surface tension of the intestinal contents in the region of the ileocaecal valve and has found it to be 40 dynes, thus adding weight to this suggestion. Further review of the cultural characteristics and implantability of *Lactobacillus acidophilus* is impossible in the scope of this paper. Extensive bibliographies are to be found appended to the books and many papers on this subject.

It is our hope that with another year of study we will have accumulated a sufficient amount of material to present a detailed analysis of the clinical value of *Lactobacillus acidophilus*. We wish at this time to present a preliminary report only, a summary of the results of our studies thus far. Our observations have been made upon patients in private practice and upon groups of patients in the Cook County Hospital.

Thus far we have confined our studies almost entirely to the results obtained by the administration of acidophilus milk. We have insisted on a milk that contained at least 300,000,000 viable organisms per cubic centimeter and one that was not more than a few days old. Inasmuch as it is important to get the culture into the lower bowel as quickly as possible in order to keep it viable, it was directed to be taken between meals and at bedtime, with the stomach empty or nearly so.

At the outset, we advised a quart of acidophilus milk in divided doses and as soon as the stools showed a satisfactory implantation, the daily dose was decreased to two glasses, and, after a few weeks, a glass at bedtime often sufficed. In the cases where the stools did not show acidophilus bacilli, lactose in doses of  $\frac{1}{2}$  to 2 oz., was added to each portion of the milk. When the patient objected to the taste of the milk, the flavor was altered by using fruit extracts or chocolate. Occasionally, patients were found to have no tolerance for milk proteins. These were given broth culture and lactose in fairly large amounts and this was supplemented, when necessary, by rectal injections of the same culture. In a few cases, we have used a chocolate-covered agar preparation which we have found to contain viable organisms. Even though we used a satisfactory acidophilus milk there was a great variation in its implantability in the colon. Some patients developed a good aciduric flora in their stools within a day or two while in others a week or more was required to bring about this desirable change. In a few we could not demonstrate any acidophilus bacilli at any time even though maximum doses of the milk were given. When we were not able to obtain an aciduric flora by oral administration, in some instances we resorted to a thorough cleansing of the colon with a high enema and then injected several ounces of a broth culture on several successive days. At the same time we gave maximum doses of milk and lactose by mouth. By this method even the most stubborn cases were changed to the desired flora.

During the early stage of the treatment the patient sometimes complained of gaseous distention. This was probably due to the action of the resident gas-producing organisms on the lactose of the milk. Such disturbance was readily relieved by an enema. As soon as the acidophilus organisms gained the ascendancy in the stools the trouble disappeared.

The following laboratory procedure has

been adopted in the examination of the preparations used and of the stools: Fecal specimens from the patients under observation were delivered at the laboratory at stated intervals and were kept in the ice box until plated. The specimens were then thoroughly shaken in sterile distilled water with glass beads and diluted with distilled water following the method of Rettger and Cheplin. Platings were made using the tomato extract agar of Kulp. This medium was found to be most satisfactory for the growth of the *Lactobacillus acidophilus* organism. The plates were incubated for forty-eight hours at 37°C. At the same time that the platings were made, smears were prepared for gram stain differential count. In one series the plates were incubated in an atmosphere of 10 per cent CO<sub>2</sub> as suggested by Valley and Rettger, but gave no appreciably different count from duplicate plates incubated in the usual manner. We are, therefore, of the opinion that the value claimed for incubation in an atmosphere of CO<sub>2</sub> is not sufficient to warrant its use in this type of work. We feel further justification in this by the close agreement always obtained between our plate counts and stained smears and by the fact that a 98 per cent implantation could be demonstrated on our plate counts. The acidophilus containing products used in this investigation were frequently plated in this manner and were thus checked with respect to their content of viable organisms.

Briefly summarized, the results of our studies thus far indicate that in most instances, coincident with a demonstrable implantation of *Lactobacillus acidophilus*, an improved clinical picture is obtainable in those patients with symptoms of direct or indirect intestinal origin. The completeness of the improvement varies with the individual and with the degree of implantation obtained. We were early impressed with the fact that no one dosage of any preparation will accomplish an adequate implantation in every individual and that mass doses, regularly administered, are necessary.

We have studied a relatively large group of cases involving chronic constipation. When the constipation was not associated with structural changes, a definite benefit was obtained. Approximately 80 per cent were relieved and the majority of the remainder showed improvement. The stools became regular, of bulky, soft consistency, and lighter in color, and the gram-positive organisms often exceeded 90 per cent of the fecal flora. An especially interesting study of constipation was done with a group of bed-ridden patients in the fracture wards of the Cook County Hospital. Those patients of this group in whom implantation of *Lactobacillus acidophilus* was successful were relieved of their attendant constipation and had regular free bowel movements, so long as treatment was continued.

A small group of cases of chronic diarrhea has been available for study. Of these cases, only those not associated with ulcerative lesions were definitely relieved. A few cases of mucous colitis that had stubbornly resisted other measures showed improvement following the successful implantation of *Lactobacillus acidophilus*.

We have studied a heterogeneous group of cases with symptoms of probable intestinal origin. In practically all of these some clinical improvement was observed with alteration of the flora to an aciduric type. A typhoid carrier who had obstinately resisted all efforts to obtain a typhoid negative stool recently came under our observation and was given one quart of acidophilus milk a day. Coincident with a demonstrable implantation of *Lactobacillus acidophilus*, the stools became free of typhoid organisms.

We have frequently employed a diet consisting of milk, cereals, vegetables, fruits, including the natural dextrines, and in which animal proteins were given in minimum amounts. We have felt that such a diet is of assistance in developing an aciduric flora and in delaying the disappearance of the flora after the administration of the organisms has been stopped.

# INTESTINAL OBSTRUCTION\*

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EXPERIENCE in the diagnosis and therapeutic handling of intestinal obstruction has created a greater respect for the differences in localization and etiology than can be expressed by the unqualified diagnosis. The differences are so great and the individual problems so specific that intestinal obstruction becomes only a general heading in the individual case. The following cases illustrate and emphasize both the educational and practical importance of this conception.

The important considerations in the general management of patients with intestinal obstruction have been admirably summarized by Haden,<sup>1</sup> McVicar<sup>2</sup> and others; and the life-saving value of hypertonic glucose-saline solution in reducing the toxemia and operative risk is now generally appreciated. Morton<sup>3</sup> and Cooper<sup>4</sup> have recently summarized in a most comprehensive and excellent manner the various experimental contributions to our knowledge of intestinal obstruction, and have assembled a very complete bibliography relative to the mass of literature, which has accumulated upon this subject. This comprehensive literature deals mainly with the experimental rather than with the clinical aspect of the problem. There is need for further clinical discussion of this subject.

CASE 1. A man of forty-five years, who had received a compression fracture of the first lumbar vertebra, was put to bed in a plaster cast in the usual hyperextension position of the spine. A few hours after application of the cast by the orthopedist the patient developed upper abdominal pain and nausea, which persisted, and was followed a little later by vomiting. Gastric lavage and enemas afforded no symptomatic relief. A little later definite distention developed, along with more marked, upper abdominal pain, and pronounced exacerbation of the vomiting. A plain film of the

abdomen, taken at this time, revealed dilatation of the loops of the small intestine with gas and the so-called step-ladder appearance. It was now apparent that the patient had developed a paralytic ileus. The plaster cast was, therefore, promptly cut away, the patient was taken out of the hyperextension position, and was asked to get up to walk about his room. Following this activity he developed repeated belching of gas and passage of flatus, and several hours later, a compensatory diarrhea, with prompt subsidence of vomiting, pain and distention. The patient was then given a back brace, and advised to remain up and about. He tolerated this very well until an attempt was made to introduce a little more hyperextension into the brace, whereupon there was recurrence of gastrointestinal symptoms, and it became necessary to resume the use of the original brace.

*Comment:* We have seen 3 cases of this type, with an adynamic ileus developing when the patient was placed in a hyperextension cast. In the other 2 cases it also became imperative to remove the cast before any relief of symptoms could be obtained.

CASE 11. A boy, aged eight years, developed a pneumococcus peritonitis as a complication of an infectious mononucleosis (glandular fever), Type 1 pneumococcus being isolated from the blood. He then developed a gastrointestinal ileus as a complication of the peritonitis, with marked distention, repeated vomiting, and abdominal pain. About sixty hours after the onset of peritonitis the boy rather suddenly went into a condition of circulatory collapse, his pulse rate increasing from 120 to 155, with the development of a thready quality. Repeated administration of hypertonic, glucose-saline solution,<sup>5</sup> gastric lavage, and enemas had not afforded relief; exodus seemed imminent. Since all other measures had failed, we decided to try the effect of passing a nasal tube into the jejunum, in the hope that we might thus relieve the overdistention handicap of the smooth muscle

\* From the Gastro-Intestinal Division of Medical Department, Henry Ford Hospital. Read at the Thirty-third Annual Meeting, American Gastro-Enterological Association, Atlantic City, May, 5, 1930.



tonus, and if improvement followed, circumvent his vomiting by tube feeding. After one hour of careful manipulation with control x-ray films, using a portable apparatus, we succeeded in passing the tube about 6 in. beyond the duodenojejunal flexure into the jejunum. We were immediately able to aspirate a large quantity of gas from the upper part of the small intestine, whereupon the pulse rate promptly dropped from 155 to 125, with striking improvement of the general condition. For the next ten days we fed this patient through the jejunal tube, with very satisfactory results and improvement in the general condition. There was some dilatation of the stomach for a few days, but the gastric tympanitis was controlled by periodically passing a second tube into the stomach when necessary. On such occasions evidence of the intestinal phase of gastric secretion was always encountered after aspirating the gas, but the gastric contents were re-fed through the jejunal tube to aid in the maintenance of the blood chloride level. After two weeks of such treatment, when the patient's general condition was apparently much improved, and the jejunal tube had been removed, there was an unexpected, final complication of convulsions, followed by coma, and, a little later, by exodus. Autopsy revealed the characteristic gelatinous exudate of pneumococcus peritonitis, and, in addition, two large, recent perforations of the small intestine some distance below the lowest point of introduction of the tube.

*Comment:* Although this patient expired following the terminal complication of perforation, the case illustrates the value and feasibility, in cases of paralytic ileus in which other measures have failed, of relieving the over-distention of the small intestine by the introduction of a nasal tube into the jejunum. The beneficial effect of this procedure upon the patient's circulatory collapse was very striking; and the nutritional problem, resulting from the vomiting, was also solved.

CASE III. A man of thirty-five years had had, for one year, recurring periods of paroxysmal, upper, mid-abdominal pain, with associated vomiting. In the last attack some bright red blood was noted in the stools. On abdominal examination an extremely tender,

transversely placed, sausage-shaped mass could be palpated in the upper mid-abdomen.

During the barium enema examination the colon filled only up to about the mid-portion of the transverse colon, where the barium column terminated with a characteristic,<sup>6</sup> central, filling defect, surrounded by the transverse, haustral markings, usually seen in this condition. Further administration of the barium simply led to dilatation of the distal half of colon, with continued non-filling of proximal portion. A six-hour barium meal examination showed dilatation of the terminal ileum, some barium in the distal part of transverse colon, and in the descending colon, but again, non-visualization of the proximal colon.

Abdominal operation revealed a firm, cylindrical mass, measuring 8 cm. in diameter and 15 cm. long, consisting of an intussusception of the cecum, ascending and proximal part of transverse colon into the distal portion of transverse colon. The intussusception was gradually reduced, and a pedunculated mass was then felt in the base of the cecum. The ascending colon and cecum were very mobile. Since the wall of the proximal colon was markedly indurated and congested, the bowel was not opened at this time, but the cecum was brought into the wound and sutured to the peritoneum. A few days later the cecum was opened, and a lipoma, the size of a hen's egg, was removed. Convalescence was uneventful. There have been no further obstructive symptoms.

*Comment:* This case illustrates the characteristic clinical, laboratory, roentgen-ray, and operative findings in intussusception of the proximal colon. The finding of a lipoma is, of course, not a constant one in such cases, although one type or another of tumor mass is frequently found. The case also illustrates one of the possible complications of a mobile cecum and ascending colon.

CASE IV. A man aged thirty years, had been annoyed for two and a half years with recurring periods of dull, left-upper quadrant pain, with associated vomiting, and marked constipation. There had been no attacks of severe, abdominal pain, and there had been short intervals of freedom from these symptoms. Physical examination was negative



except for moderate tenderness all over the left side of the abdomen. No masses were felt.

Roentgen-ray examination showed the large bowel entirely in the left side of the abdomen, with a mobile cecum and ascending colon, and the usual findings of non-rotation of the colon.

Operation performed by a surgical colleague<sup>7</sup> confirmed the roentgen-ray findings. There was a short mesentery binding the two limbs of the transverse colon into a long, narrow U. The cecum and ascending colon were very mobile, and the ileum entered the right side of the cecum. At the time of operation there was no actual volvulus of the terminal ileum with the mobile cecum and ascending colon; but it was apparent that there had been torsion.

In order to prevent further volvulus, the cecum and ascending colon were sutured to the anterior abdominal wall along the line of closure of the abdominal incision. The antero-posterior septum of the abdomen, thus formed, made it impossible for the terminal ileum to cross again over the cecum and produce a volvulus. Convalescence was uneventful, and obstructive symptoms disappeared.

*Comment:* Volvulus of the cecum and ascending colon, although a rather rare condition, represents a second, possible complication of a mobile cecum and ascending colon. The degree of developmental defect present varies in such cases of volvulus; and the exact type of surgery indicated varies accordingly.

**CASE V.** A young woman, aged twenty-eight years, presented clinical, laboratory and roentgen-ray evidence of pyloric obstruction. The history and absence of occult blood in the stools suggested a benign type of obstruction, whereas the irregularity of the extreme distal end of the antrum in the serial films suggested the possibility of malignancy.

At operation a large, firm, irregular mass was found at the pylorus, involving the adjacent duodenum and stomach wall. Posterior gastroenterostomy was performed, and, since the appearance of this mass suggested malignancy, it was decided to resect the mass at a subsequent second-stage operation. However, at the second operation, thirteen days later, it was found that the mass had entirely disappeared. The pylorus now admitted two fingers, and the only pathology consisted of a small prepyloric ulcer.

This patient was operated upon seven years ago, just before we had started the routine practice of subjecting our pyloric obstruction cases to a preliminary period of medical management, with intravenous, hypertonic, glucose-saline solution, gastric aspiration each evening, and frequent small meals, in order to improve the patient's condition for surgery if the obstruction persists, and to determine those cases in which the obstruction completely disappears during such a period of preliminary medical management. This patient might not have come to operation if this preliminary medical treatment had been carried out at that time.

*Comment:* This case illustrates the rapidity with which a mass of inflammatory swelling in the pyloric region can entirely vanish when the physiological rest of the stomach is restored. It also illustrates the fact that it is not always possible at operation to determine the benign or malignant character of the pyloric mass; and it is, therefore, essential to obtain a maximum amount of diagnostic information on this point before operation. The ulcer in this case was prepyloric, although it is usually on the intestinal side of the pylorus in these cases of benign pyloric obstruction.

**CASE VI.** A man of fifty years had had chronic obstructive symptoms for several years. The morning vomitus usually contained a large quantity of bile, and frequently food eaten the previous evening. Relief of the epigastric distress was obtained only from vomiting. During barium meal fluoroscopic examination the barium was seen to pass rapidly through the stomach and duodenum, but there was moderate barium delay in the upper 24 in. of the jejunum, with evidence of definite dilatation of this segment of the small bowel.

Abdominal surgery was decided upon, and operative findings disclosed a very marked dilatation of the duodenum and upper 2 ft. of the jejunum, with a diameter almost equal to that of the colon. At the lower limit of this dilated segment there was no band of adhesions, kink, or other mechanical obstruction to be made out; and the jejunum shaded off in its diameter into normal looking, small intestine.

Enteroenterostomy between the dilated por-

tion of the jejunum above and the narrow, normal jejunum below did not relieve the obstructive symptoms; but a subsequent duodenojejunostomy operation afforded complete and permanent relief of symptoms.

*Comment:* The marked dilatation of the upper portion of the small intestine and the obstructive symptoms in this case were probably due to a localized, congenital defect in Auerbach's plexus, causing chronic, partial, paralytic ileus of the upper portion of the small bowel.

CASE VII. An unmarried woman, aged thirty-seven years, had had a reverse peristalsis syndrome, with frequent belching of gas, regurgitation of food, and vomiting after meals for a period of several years. These symptoms were more marked late in the day after she had been on her feet a number of hours. Barium meal examination revealed no six-hour retention, but immediate fluoroscopic examination of the duodenum showed definite dilatation of the duodenum, with delay in the passage of the barium through this segment, and with vigorous anti-peristaltic waves sweeping back over the duodenum to the pylorus. These fluoroscopic findings were present with the patient in various positions.

A diagnosis of chronic duodenal ileus was made, and the patient was placed upon a trial regime of medical management, with an abdominal support, rest periods after meals, and a high caloric, bland diet. The symptoms were only partially alleviated, and continued to be quite annoying. Surgery was, therefore, decided upon. At operation marked dilatation of the duodenum was found, along with considerable induration of the mesentery and mesenteric vessels as they looped over the duodenum. A duodenojejunostomy operation was done, with subsequent complete disappearance of the anti-peristalsis syndrome, gain in weight, etc.

*Comment:* Although medical treatment affords satisfactory results for the less marked cases of duodenal ileus, the cases with more pronounced obstruction obtain complete relief only with duodenojejunostomy.<sup>8</sup> The diagnosis of chronic duodenal ileus is not justified unless there is clinical evidence of anti-peristalsis, and unless

the essential roentgen-ray criteria are all present.

CASE VIII. A woman, aged forty-eight years, gave a history of chronic obstructive symptoms, with occasional vomiting for eighteen months, and daily vomiting for five weeks, occurring regularly from one to two hours after practically every meal. She had lost 30 lb. in the last five months. Using the single barium meal method in this case, the barium was seen to pass rapidly through the stomach into a dilated duodenum, and then into an extremely dilated jejunum. About 15 in. distal to the duodenojejunal flexure an almost complete obstruction of the jejunum was encountered. The barium column at the point of obstruction presented a rounded contour. There was a large six-hour and twenty-four-hour retention of barium in this loop of the jejunum. Stool specimens persistently showed a positive guaiac test.

A preoperative diagnosis of high grade jejunal obstruction, probably due to carcinoma, was made. The occult blood in the stools, and the gradually progressive character of the symptoms suggested carcinoma as the probable cause of the obstruction.

At operation an annular carcinoma of the jejunum was found. The local growth was excised, and lateral anastomosis done. Unfortunately there was evidence of metastases to neighboring glands, and to the omentum. Deep x-ray therapy was employed, but the patient's course was gradually downward with successive complications due to metastatic malignancy. Death occurred nine months after operation.

*Comment:* The ultimate outcome in this case might have been different if the patient had not procrastinated for eighteen months after initial obstructive symptoms before she consulted a physician.

CASE IX. A man of thirty-seven years, was taken suddenly with very severe, generalized, intermittent, cramp-like, abdominal pain. Paroxysms occurred about every three minutes. Bowels had moved twenty-four hours before, and there was no abdominal distention. While the patient was being observed for several hours, he vomited once or twice, paroxysms of pain became more severe, he developed a leucocytosis, and the pulse rate increased to 90. An enema gave no relief of pain. Some diffuse abdominal tenderness was noted,

but no palpable mass. The blood chlorides were found to be moderately depressed. Previous history was essentially negative except for appendectomy eighteen months before.

A diagnosis of acute intestinal obstruction was made, and operation decided upon. While the hypertonic glucose-saline solution was being prepared for intravenous administration, the pulse suddenly rose to 120, the temperature increased from normal to 101°F., and beginning distention of the upper abdomen appeared. The pulse dropped and the general condition improved promptly and strikingly with administration of the hypertonic glucose-saline solution. At operation a right rectus incision revealed a constriction of the cecum due to a single heavy band of scar tissue, causing dilatation of the small intestine above this point. This band of scar tissue was removed. Several hours later the pulse rate again increased rapidly. Again hypertonic glucose-saline solution was given intravenously, whereupon the pulse promptly slowed down, coincidentally with development of diarrhea and expulsion of flatus. The patient then made an uneventful recovery.

*Comment:* In this patient the development of critical, toxic manifestations was twice arrested, within an eight-hour period before and after operation, by the intravenous administration of hypertonic glucose-saline solution. As emphasized by McVicar and others, the sodium chloride, glucose and water each plays an important rôle in this intravenous medication for patients with intestinal obstruction.

CASE X. A woman, aged thirty-five years, who had had cholecystectomy and hysterectomy, and was known to have rather dense adhesions in the right upper quadrant, gave a history of periodic vomiting for several years, and for several months had had daily vomiting of considerable quantities of food, with rapid, progressive loss of weight. There was no occult blood in the stools. Fluoroscopic examination showed dilatation, delayed passage of barium, and anti-peristalsis in the duodenum. A diagnosis of duodenal obstruction was made; and it was felt that the obstruction was probably due to adhesions involving the third portion of the duodenum.

At operation the main obstruction was found to be due to dense adhesions in close proximity

to the point where the mesenteric vessels cross the duodenum. Fortunately it was possible to separate the periduodenal adhesions sufficiently to do a duodenojejunostomy operation, and drain the duodenum. A gastroenterostomy would obviously in no way have solved this patient's problem. Operation was followed by a disappearance of obstructive symptoms and a progressive gain in weight.

*Comment:* In view of the possible, mechanical difficulty of doing a duodenojejunostomy amidst a mass of adhesions, this was the type of case in which one was naturally reluctant to subject the patient to another operation. However, the patient's progressive loss of weight and strength made surgery imperative, and the outcome was very gratifying.

#### SUMMARY

A group of patients with intestinal obstruction have been reviewed with lantern slides of roentgen-ray or operative findings. These cases illustrate problems of etiology, diagnosis or therapy in patients with intestinal obstruction, acute or chronic, partial or complete, and functional or organic, at different levels of the intestinal tract.

The group includes such conditions as paralytic ileus, intussusception of the proximal colon, volvulus of the cecum and ascending colon, pyloric obstruction due to inflammatory swelling, congenital defect in Auerbach's plexus, chronic duodenal ileus, carcinoma of the jejunum, periduodenal adhesions, and post-appendectomy, periceal adhesions.

The conditions referred to as intestinal obstruction comprise such a wide variety of individual problems in diagnosis or therapy, that the unqualified use of this broad, generic term fails to specify the real nature of the problem. Although the term may still have value in general considerations, a great deal would undoubtedly be gained in the training of medical students and hospital interns by placing greater stress upon the essential importance of not making a diagnosis of

intestinal obstruction without qualifying, or at least attempting to qualify, in each instance, this generic diagnosis with the specific type of obstruction present.

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#### DISCUSSION

DR. LICHTY: I would like Dr. Mateer to tell us what became of the patient who had the congenital defect of Auerbach's plexus. What was the outcome of the case?

DR. WHITE: I should like to ask Dr. Mateer whether he regards it a safe practice to give a barium meal to patients with intestinal obstruction.

DR. SMITHIES: I would like to know whether there were any chemical changes in the blood, as a result of these conditions, or whether the blood chemistry seemed to remain normal.

DR. MATEER (closing): In regard to Dr. Lichty's question as to the ultimate fate of the patient with a congenital defect in Auerbach's plexus, we neglected to state, although it is pointed out in the main body of our paper, that this patient obtained little or no relief from an enteroenterostomy operation between the dilated jejunum above and the normal jejunum below. However, he subsequently had a duodenojejunosomy operation, with direct drainage of the duodenum, several years ago;

and he obtained complete and apparently permanent relief from this operation.

Dr. White's question as to whether we regard it a safe practice to give a barium meal in these obstruction cases is quite pertinent. If there is clinical evidence of some degree of intestinal obstruction we practically never give a barium meal until we have observed the patient sufficiently to evaluate as accurately as possible the degree of obstruction. If there is evidence of high grade obstruction the barium meal is omitted as a rule. If our observation suggests a low grade of obstruction, and if our clinical, laboratory and barium enema information fails to localize the lesion, we give a small barium meal. In the intussusception case referred to, the lesion was localized by the barium enema; and the barium meal examination was, therefore, superfluous, and should have been omitted.

We heartily agree with Dr. Smithies' emphasis of blood chemistry studies. Such studies are carried out routinely in our clinic upon obstruction cases, and I recall that the findings were particularly interesting in 2 of the cases, which we have discussed. In the instance of the boy with acute gastrointestinal ileus and pneumococcus peritonitis, the usual findings of a high  $\text{CO}_2$  and blood urea and low blood chlorides were present; and we were unable to restore the normal blood chemistry with repeated intravenous, hypertonic, glucose-saline injections until we had introduced the nasal tube into the jejunum, and subsequent cessation of the vomiting had occurred. As noted in the main body of our paper, our ninth case, a patient with obstruction due to a band of pericecal adhesions, developed a tachycardia and other so-called toxic symptoms and signs, in addition to a depression of the blood chlorides, both just before and again a few hours after the operation. On both occasions the tachycardia and other untoward manifestations promptly disappeared with the administration of hypertonic, glucose-saline solution. Dr. Haden and Dr. McVicar deserve a great deal of credit for having emphasized the importance of blood chemistry changes in these cases, and the therapeutic value of intravenous hypertonic, glucose-saline solution.



# SURGICAL MEASURES IN THE TREATMENT OF LUNG TUBERCULOSIS\*

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THE application of surgical principles to the therapy of lung tuberculosis has revolutionized the treatment of certain phases of this disease. A new attitude was determined in this country when artificial pneumothorax, originated by Forlanini in the early 80's, received belated acceptance, and this position was reinforced by the introduction of extrapleural thoracosplasty. Recently the field of surgical therapy has been further extended by the adoption of phrenicectomy, which has aroused enthusiasm among those who have observed its results.

Inasmuch as the application of these measures has been generally established in the more advanced tuberculosis centers in this country and Europe, it may be timely to consider their scope and limitations, and, so far as possible, formulate provisionally the indications for their employment.

## RATIONALE

The lung is handicapped in its efforts at repair by constant motion in expansion and contraction. Surgery is applied primarily for the purpose of providing physiological rest to the lung tissue. It aims to immobilize the lung by allowing it to deflate. Its function as a blood-aerating organ is thereby suspended in varying degree, while the intrinsic circulation, vital to healing, is maintained intact or promoted by the state of rest.

A secondary and important purpose is to induce collapse of cavities, where such exist. Negative pressure in normal states maintains the visceral pleura in constant and intimate contact with the parietal pleura in such fashion that the walls of an abscess cavity cannot fall together, as they do in soft tissues generally throughout the body, in the process of healing. This state of affairs encourages continued ulcerative

erosion, with incidental hemorrhages and prolonged absorption of toxic decomposition products. Healing becomes difficult or impossible so that even in favorable cases, which show their resistance by becoming chronic, cavities persist indefinitely. If this physiologic tension on the walls of a recent cavitation is released, the natural contractility of the lung tissue asserts itself, and the cavity collapses as part of the general retraction.

A third consideration is based upon the fact that under collapse therapy toxic symptoms in progressive cases are seen to diminish or disappear. Fever subsides, the pulse rate is reduced, and cyanosis, emaciation and general malaise subside. One explanation offered to account for this observation is that compression of the lymph vessels draining the lung reduces the absorption of the products of infection.

To induce physiologic rest through deflation of the lungs, three methods have been devised. The *first*, artificial pneumothorax, depends upon the introduction of air or nitrogen gas by intercostal puncture into the potential space between parietal and visceral pleura, thereby overcoming the negative pressure which holds the lung to the chest wall, and allowing it to retract and shrink back onto the hilus. The *second* method, phrenicectomy, aims to lessen the functional activity of the lung and to reduce the effective size of the thoracic cavity by paralyzing the diaphragm on the affected side through destroying the function of the corresponding phrenic nerve. The *third* method, extrapleural thoracosplasty, aims to eliminate completely and permanently the function of one side of the chest by removing through the back a section from all the ribs which partake in the respiratory function.

Each of these procedures has its own indications and field of application, which

\* Read at a meeting of the Staff of the Sanatorium Division of the Boston City Hospital, October 29, 1930.

we will consider separately, emphasizing phrenicectomy, upon which just now attention is being focused.

#### ARTIFICIAL PNEUMOTHORAX

Artificial pneumothorax has been in common use throughout this country for some years, has proved a valuable adjunct to treatment, and has been generally accepted within certain limits. The technique is familiar and needs no description here. Under aseptic precautions and with x-ray control, a measured amount of air or nitrogen is injected under measured pressure into the interpleural space at increasing intervals. The treatment period is from six months to three or four years.

The air or gas injected between the parietal and visceral pleura releases the negative pressure which keeps them in contact, and the pull of the chest wall upon the lung in inspiration is broken. Thereupon, by its inherent elasticity, the lung tissue shrinks and its air spaces collapse, until a balance is reached between its contractility and the interpleural pressure. The respiration continues, but is naturally diminished in proportion to the amount of collapse, which makes it imperative that the other lung be in proper condition to maintain sufficient aëration for bodily function.

This method does no irreparable harm, as the agent is absorbed and the lung function gradually returns after treatment is suspended. It is recommended for general application in unilateral cases, especially in cases of early infiltration, moderately advanced cavities in the early stages of development, and cases not doing well under the rest routine. It is recommended in cases of spontaneous pneumothorax, after complete absorption of the air, in serous pleurisy or tuberculous empyema, and it is valuable as an emergency proceeding in uncontrollable pulmonary hemorrhage. The method is associated with danger in acute and rapidly advancing cases, as it is severe and may cause dissemination.

Unfortunately, many cases selected for

artificial pneumothorax present adhesions in some degree, and this interferes seriously with its use. It is estimated<sup>1</sup> that in about 20 per cent, adhesion of visceral to parietal pleura will prevent the introduction of gas. In another 40 per cent adhesions are present of such character as to prevent the collapse necessary to provide adequate functional rest, or closure of cavities. This leaves about 40 per cent of unilateral cases in which a satisfactory pneumothorax can be carried out. If, after several months' trial, the x-ray reveals that an affective collapse has not been obtained, the method is abandoned. It should be borne in mind that localized adhesions usually occur over diseased areas, the particular regions where collapse or compression is most desired.

The method should only be employed where one lung is unaffected, or has no more than a small circumscribed apical lesion which will not be disturbed by the increased functional burden. It cannot be used in early caseous pneumonia, and cases with pneumonic infiltrate, where contractility is interfered with. It is contraindicated in patients with chronic non-tuberculous lung affections such as bronchitis, emphysema or asthma, or with severe intercurrent disease, such as intestinal tuberculosis, cardiorenal disease, or diabetes.

There are certain complications and unfavorable sequelae, for instance pleural shock, perforation of the lung, with spontaneous pneumothorax, permanent contraction of the lung, displacement of the mediastinum, and bronchiectasis.

By far the commonest complication is pleural effusion. Many cases under long-continued treatment develop an exudate. Sauerbruch<sup>2</sup> gives the figures as 30 to 50 per cent or higher. O'Brien<sup>3</sup> goes so far as to say that nearly all patients undergoing artificial pneumothorax develop some fluid eventually. A simple serous exudate can become infected, secondary to an acute generalized infection such as tonsillitis, influenza, furunculosis; or directly from internal sources through perforation of a cavity; or externally through wound infection or lack of asepsis in technique; and



then become purulent. It is roughly estimated that empyema arises in from 5 to 10 per cent of all cases showing any considerable amount of fluid. Intercurrent empyema of a mixed infection type offers a serious prognostic outlook.

#### PHRENICECTOMY

Paralysis of the diaphragm for the purpose of giving functional rest to the lung in pulmonary tuberculosis was first employed by Stürtz in 1911. It was taken up in Germany, spread into France, and was soon adopted in this country. The extent of its use is shown by the size of the series of cases recently reported; for instance, in Germany Wirth and Jaski<sup>4</sup> report 600 cases, Graf<sup>5</sup> 136, and Sachs<sup>6</sup> 136. In France Berard and Lardennois<sup>7</sup> 120, and Dumarest, Mollard and Guiraud<sup>8</sup> 120. In America Welles<sup>9</sup> has reported 300, and O'Brien<sup>10</sup> 500 cases. These and other series indicate the extent and rapidity of its adoption.

Whereas artificial pneumothorax is a simple procedure generally carried out by the physician, which may be done in the home, phrenicectomy is an operation, requiring a surgeon and an operating room. It consists in locating the phrenic nerve on the affected side on its way down the neck, and either crushing it, dividing it, excising a segment, or completely avulsing the nerve down to the diaphragm. The effect is paralysis of the half of the diaphragm on the operated side.

Crushing the nerve can be expected to cause a paralysis which persists five to six months. Excision of a segment, or complete avulsion (exeresis), causes permanent paralysis (although Wirth and Jaski report that 12 per cent of their cases done three to five years before show a normally functioning diaphragm). Whereas crushing or alcoholic injection was used commonly in the early days of the procedure, it has been found in practice that crushing allows too little time as a rule for complete healing. O'Brien reports that 90 per cent of his cases had to be reoperated for removal of the nerve. Now crushing is usually re-

stricted to minimal lesions or to alternating bilateral collapse.

As between division and exeresis it must be borne in mind that in a certain proportion of individuals (roughly estimated at 25 per cent) other branches of the sympathetic system in the form of collateral or accessory nerves transmit motor impulses which help innervate the diaphragmatic muscles. These join the phrenic bundle lower down in its cervical or thoracic portion, and to assure complete paralysis they must be included in the procedure. In unusual instances these collaterals run to the diaphragm as separate nerves, or the lower intercostal nerves participate. Complete avulsion of the phrenic nerve down to the diaphragm (12 to 16 or more inches) is recommended because it insures pulling out the accessory fibers, or breaking them off at their point of junction with the main trunk.

But in practice exeresis is very painful, requiring during part of the operation an inhalation anesthetic, and otherwise increasing the danger of the procedure. A collateral may hook about a thin vessel, which if torn, allows possibilities for serious hemorrhage. On the other hand, it has been found that the operation fails only rarely through independent collateral innervation, so that ordinarily the nerve is twisted up enough to insure the attachment of any collaterals being broken, and a segment of 3 in. or more is excised. Accessory nerves are sought for in relation to the phrenic, and if found are also excised.

The operation is technically simple, but it should not be attempted by one not thoroughly conversant with the local anatomy. It can be done satisfactorily under novocaine anesthesia, particularly if preceded by scopolamine and morphine. But a gas-oxygen apparatus should be on hand to use if necessary for the final "twisting out" process. A good "spot" light will be a material help in identifying structures.

An incision  $1\frac{1}{2}$  in. long is made two fingers breadths above the clavicle and parallel to it, centered on the posterior



border of the sternomastoid muscle. The edge is identified, freed, and retracted forward. This exposes a pad of fat, which has to be separated carefully, to lay open the scalenus anticus muscle directly below; carefully, because at this level one may encounter an unexpected vein or nerve, a lymph node, or the thoracic duct.

Under the thin transparent fascia covering the scalenus muscle the nerve is apparent running in the direction of the muscle fibers, and lying between them. It is identified by the reaction to pinching; a sharp pain is referred to the shoulder of the same side, or to the diaphragm. It is freed up, lifted out on a hook, injected, divided, twisted out slowly for the desired length, and the segment removed. If accessories can be identified, a segment is excised from these also. With care there will be no bleeding points to require ligature. A couple of zero catgut sutures are placed so as to approximate the edges of the deep fascial plane, and a subcuticular stitch closes the skin wound.

I have found in practice that the dissection may be somewhat more difficult in women, because they are apt to have a thicker fat pad behind and under the sternomastoid. On the left side one must keep in mind the thoracic duct. The smaller deep veins of the neck follow no set rule in their meanderings, and have to be watched for, particularly because when empty they sometimes resemble a thin fascial band; the nerves carry no labels.

The various operative dangers usually listed are: injury or division of a large vessel, division of the pneumogastric or recurrent laryngeal nerve, or one of the cervical sympathetics, or the thoracic duct.

Immediately after the operation the paralyzed half of the diaphragm rises into the chest cavity as a result of intra-abdominal pressure, and becomes stationary. Elevation up to 9 cm. and over has been observed, with an average of 2 or 3 cm. The rise may not appear until later. The hemidiaphragm becomes flaccid and partakes no longer in respiration. As a

result the respiratory activity of the lung, especially of the lower lobe, diminishes and the pleural volume decreases. The amount of this diminution in volume varies in individual cases; it has been estimated to average 15 to 30 per cent.

Cessation of movement in the diaphragm is considered of more importance than its elevation. Success depends upon suspension of function within the lung rather than upon diminution of the effective size of the chest cavity. The reduction in inflation and excursion of the lung restrict motion, increase blood supply, and hasten repair by allowing new tissue to form in the natural process of healing.

The immediate *physiologic effect* of hemiparalysis of the diaphragm has been studied by various observers, on dogs and on humans. The recent observations of Werner<sup>11</sup> on 20 cases, studied before and after operation, are particularly illuminating. Werner found no change in pulse rate, or in basal metabolism, to follow the procedure. The respiratory rate increased on an average 16 per cent. Vital capacity, which is regularly diminished in lung tuberculosis, was found before operation to average 50 per cent of normal. After operation there was a decrease averaging 32.6 per cent, reaching a maximum in forty-eight hours. In no case was there evidence of cyanosis or dyspnea.

The tidal air was found decreased by operation in all but 1 case; the average decrease was 26 per cent. It is likely that the sound lung responded to its increased responsibilities by an added effort, so that it can be assumed in the absence of other information that the diminution in tidal air on the affected side was appreciably greater than 26 per cent.

The oxygen consumption was found practically unchanged. The compensation for the diminished tidal air was found to lie in one group in increased respiratory labor (respiratory rate increased 28 per cent), in a second group by increased retention of oxygen from the respired air without increased respiratory labor (respiratory rate increased 22 per cent),

and in a third group by increased retention of oxygen with diminished respiratory labor, (no change in respiratory rate). These groups were about equal in number.

The results of phrenicectomy have been found encouraging by those who have had experience with it. The effects have been evidenced in severe cases by signs of detoxication, the undoubted result of immobilization of the destructive focus, contraction of the pulmonic blood supply, and improvement in the intrinsic blood and lymph circulation. In many cases the general improvement has been immediate and striking.

Welles found that 64 per cent of his series of cases were improved, 36 per cent not improved, and a rare case (usually basal) made worse. The extent of improvement varied; one group showed lowered temperature, with diminished cough and expectoration; a second group showed marked x-ray improvement, with diminution or disappearance of cavities; a third group showed disappearance of all symptoms, a practical clinical cure.

Wirth appraised his results as fully as good as those following pneumothorax.

Graf found in his series of 136 cases, complete healing in 35, improvement in 77, no change in 21, and exacerbation in 3. Of the 133 cases with positive sputum, 55 became bacillus-free. In 67 observed from two to six years, almost exclusively cavity cases, 83.5 per cent are now living; 62.5 per cent are bacillus free; and 53 per cent are able to do their regular work.

O'Brien observed that combining phrenicectomy with artificial pneumothorax proved especially effective in the closure of cavities. In 145 cavity cases, 70 per cent were closed by this method. In 50 per cent of the cavity cases in which pneumothorax alone would have been unsuccessful on account of adhesions, by combining the two methods closure was obtained. In 102 cases where the operation was done as a preliminary to thoracoplasty (cases with extensive lesions, usually with considerable fibrosis and with thickwalled cavities), in 8 cases the cavities closed, making the

thoracoplasty unnecessary. This experience has been recorded by other observers.

It is important to define the type of case to which this procedure is best adapted. At first it was assumed that its rôle was chiefly that of an accessory, that it was a good supplementary operation for increasing the action of other methods of collapse. Thus it came to be generally used as the first stage in a thoracoplasty. It was adopted in cases in which a thoracoplasty has to be postponed on account of the risk, the phrenicectomy serving to tide them over until, or prepare them for, an ultimate radical operation. It serves here also as a functional test of the other lung in anticipation of a thoracoplasty, to show the ability of the other side to stand loading.

In relation to pneumothorax, it has several indications. It is useful where attempts to induce pneumothorax have failed on account of adhesions, and it serves in cases where pneumothorax has to be given up because retraction is prevented by adhesions. It is employed as a supplementary measure in conjunction with pneumothorax, and as a substitute in cases where pneumothorax is too expensive and protracted.

It is now recognized that phrenicectomy has a definite position as a primary or independent procedure. Some authors state that wherever the advisability of artificial pneumothorax is established (excepting only the vital indication of uncontrollable hemorrhage), phrenicectomy is equally justifiable for disease processes in any lobe, for breaking down or broken down early infiltrations, and for late fibrotic disease and cavitation. Where its effectiveness can be assumed to equal that of pneumothorax, it has distinct advantages. It is a single procedure, whereas pneumothorax has to be repeated many times, taxing the patient's strength and morale, and may take years. Phrenicectomy is less dangerous, is free of embarrassing complications or sequelae, and causes less interference with the patient's routine. If phrenicectomy fails to give the desired results

after a month or two, artificial pneumothorax is still available in suitable cases.

The earlier it is done the better. After fibrosis and retraction have become manifest, the effectiveness is diminished. It is much less effective when employed after a course of pneumothorax than when done as the initial treatment, according to Wirth and Jaski, probably because of secondary indurations or adhesions, and the loss of elasticity in the pulmonary tissue and diaphragm.

In incipient lesions it hastens recovery in persons of moderate susceptibility. In inactive cases, showing little progress, it gives added rest and thus encourages healing. In advanced cases it promotes comfort by lessening cough and pain. It shows good results in early unilateral cavities; insofar as phrenicectomy allows only partial collapse, more benefit is to be expected in soft-walled cavities than in fibrotic. It should be used, however, in fibrocaceous cavities of average severity where pneumothorax has failed and thoracoplasty is impracticable.

It has, as we have seen, a wide range of application. While generally speaking its use is limited to unilateral lesions, strict unilaterality need not be insisted upon. Good general condition of the patient is not a necessary qualification. The operation should not be performed where the diaphragm is fixed by adhesions, or immobilized in a high position.

#### THORACOPLASTY

The third of the surgical methods under consideration, paravertebral extrapleural thoracoplasty, is a more formidable procedure. It is distinctly a major surgical operation, and carries with it an appreciable risk. Accordingly it is to be considered only in selected cases, which have proved refractory to other measures, particularly chronic fibroid cases with cavities which have not become obliterated in spite of evidence of retraction, and where the process remains active.

It was Quinke, in 1888, who first

advocated the removal of segments of several ribs for collapse purposes. Spengler in 1890 extended the operation to include removal of the third to the seventh. Braum was more radical, and advised removal of all the ribs from the second to tenth, and in 1908 reported 8 cases.

Sauerbruch originated the paravertebral extrapleural thoracoplasty now generally practiced. He removes subperiosteally 4 to 12 cm. of all the ribs save the twelfth, from their attachment to the transverse process of the spine forward. By 1927 he had reported over 700 personal cases. In 1925 Alexander<sup>12</sup> published a study based on the review of 1159 reported cases. About 400 have been done on this continent (Archibald).<sup>13</sup>

The operation is best done in two stages, and in dubious cases in three. Sauerbruch removes at the first stage the lower five or six rib segments, while Archibald reversing the procedure starts with the upper ribs. The operation is usually preceded by a phrenicectomy. The lung shrinks back onto the hilus, and eventually, as shown by autopsy, is transformed into a spleen-shaped lump of connective tissue.

The purpose of this operation is to collapse and immobilize the lung and render it completely and permanently ineffective for purposes of respiration. Removal of a section of the rigid bony framework of the thorax leaves in its stead a wall of soft tissue and muscle, which allows atmospheric pressure to be exerted directly upon the contents of the pleural cavity. The divided ribs lose their lifting power, which puts a stop to costal respiratory movements. The chest cavity collapses, due to the caving-in of the unsupported forward rib segments, so that its size is diminished about one-half.

A partial thoracoplasty can be done if the cavitation is limited to an upper or a lower lobe, and the rest of the lung can be classified as recoverable, provided that the total operation is contraindicated on account of the poor general condition of the patient.

This operation, in contradistinction to pneumothorax and phrenicectomy should be strictly limited to unilateral cases. The opposite side must be free of involvement, or, if affected, the process must be at a complete standstill, as proved by long observation. It should be limited in its application to adults, under forty-five years of age, of good morale, who have sufficient resistance to place them in the recoverable zone. It should not be considered in cases with myocardial degeneration, renal disease, or any concurrent chronic tuberculous or other affection which is likely to interfere with recovery. It should be done during an inactive interval, while temperature and pulse are running normal.

Generally speaking it finds its best application in chronic unilateral fibrotic cases where the general condition is good, but where sanatorium care has reached the limit of usefulness: the process is at a standstill, but return to active life is prevented by the positive sputum and the assurance of relapse. These are the cases with rigid wall cavities which cannot collapse because the walls are too stiff, or are fixed by adhesive strands to costal pleura, mediastinum or diaphragm.

The case is particularly suitable if there are present evidences of retraction, which show that healing by the formation of

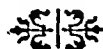
connective tissue is taking place. For thoracoplasty promotes and supplements this process. Retraction represents the contraction of the fibrous scar tissue laid down in the efforts at healing, and incidentally is an indication of resistance. The tendency to retraction is evidenced on physical examination by a flattening and diminished mobility of the affected thorax, the clavicular fossa is deepened, the ribs pulled in, and the trachea displaced toward the affected side. X-ray examination shows the rib spaces narrowed, the trachea displaced and dilated, the heart drawn over, and, if the lower half of the lung is involved, the diaphragm pulled up.

#### CONCLUSION

Surgical measures designed to collapse the lung have become established as effective in the treatment of certain phases of lung tuberculosis. A study of a series of cases reported from widely separated sources proves that these measures have prolonged many lives, and restored apparently hopeless cases to effective usefulness. Physicians treating chest tuberculosis should be acquainted with the indications for these procedures, so that they can be applied promptly when judgment dictates. And sanatoria should be provided with the surgical staff and equipment necessary for their performance.

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# TRAUMATIC FAT NECROSIS OF THE BREAST\*

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**T**UMORS in and over breasts resulting from necrosis of fat deserve general recognition. The campaign for the brings the total number on record to 46. One appreciates how important the recognition of this lesion is from the fact that

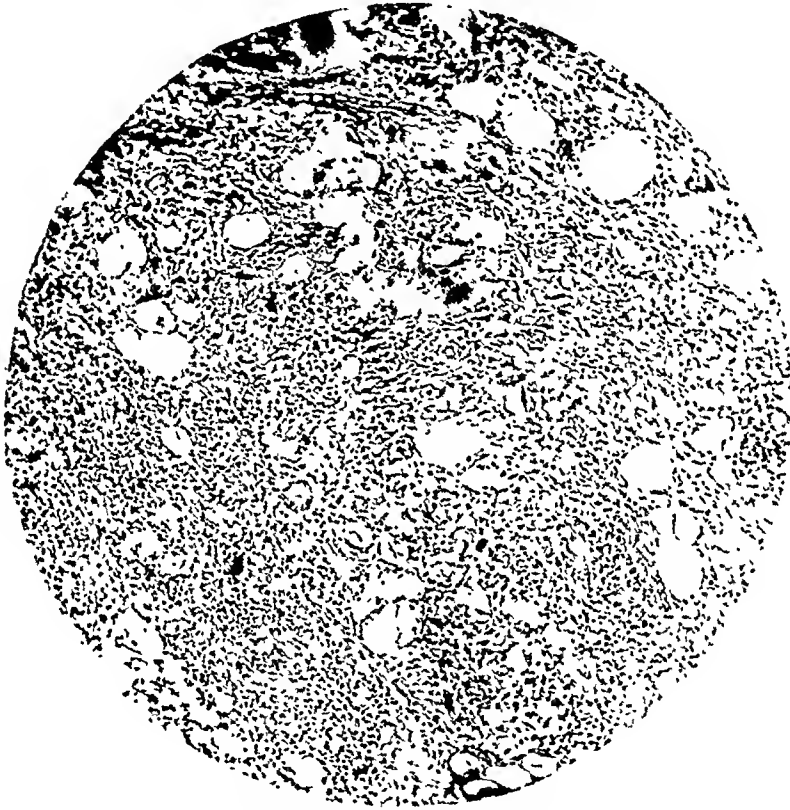


FIG. 1. Low power magnification. Note diffuse fibroblastic growth and relation of giant cells to fat droplets.

early removal of tumors of the breast is bringing to the attention of surgeon and pathologist lesions which are not only not malignant, but are also not neoplasms. Among these may be classed the tumor formed by the tissue response to localized fat necrosis of the breast. The lesion is not a common one. Hadfield<sup>1</sup> has very recently reviewed the literature, and was able to collect 42 cases, to which he added 3 of his own. The following instance, therefore,

12 of the 45 cases recorded by Hadfield had a radical operation performed for cancer of the breast.

The essential nature of the lesion is a slow, aseptic saponification of fat with resulting inflammatory response, constituting a reparative process. It is slower in development than the type of necrosis resulting from the liberation of pancreatic juice, although it is likely that the activating agent is local tissue and blood lipase. It is not necessary here to review the subject since Hadfield has so recently done so.

<sup>1</sup>Hadfield, G. Fat necrosis of the breast. *Brit. J. Surg.*, 17: 6-3, 1930.

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## CASE REPORT

Mrs. G., about sixty years of age, presented a small, hard tumor in the lower outer quadrant

and because of rather vaguely different characteristics a frozen section was made. This disclosed a fibroblastic granulomatous lesion

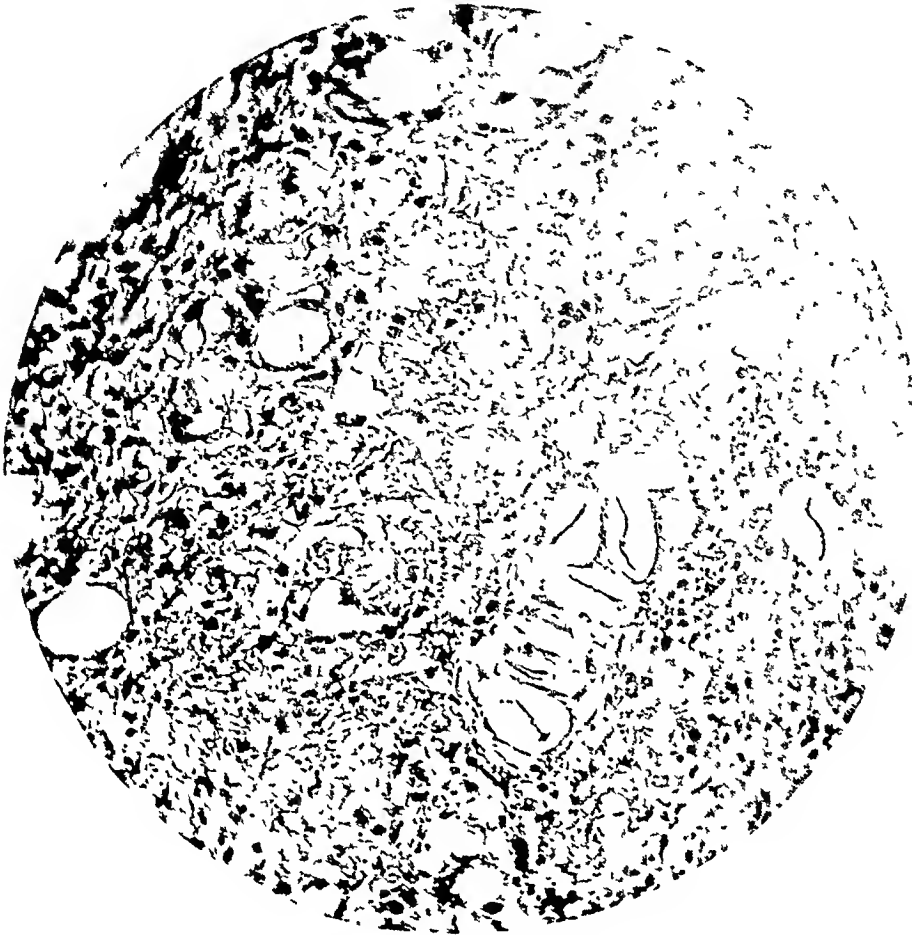


FIG. 2. High power magnification showing disposition of giant cells, oil cysts and clefts surrounded by inflammatory cells.

of the left breast, which she had observed for the first time two months previous to examination. The tumor was not painful or tender. There had not been any appreciable increase in size since the detection of the tumor. A history of trauma could not be elicited, but the lesion was placed at a point of friction between the breast and the edge of the corset. Anatomically, the tumor was in the subcutaneous fat and not in the breast tissue. The overlying skin was fixed to the mass. The excised tumor was 1.5 cm. in diameter and was hard and not encapsulated. On cross section it consisted of an opaque gray, infiltrating tissue, shading imperceptibly and irregularly into the surrounding fat. Discoloration of the surrounding fat was not observed. On superficial examination the tissue resembled a carcinoma. Yet it was sharply demarcated from the epithelium,

studded with large multinucleated giant cells. A diagnosis of foreign body granuloma was rendered. The paraffine sections made clear the nature of the lesion. It consisted primarily of an intense growth of fibroblasts compactly arranged at the periphery of the lesion and less compactly in the central and deeper portions. Outstanding was the large number of multinucleated giant cells. These varied considerably in size and in the number of nuclei. Frequently, the outline of the giant cells was irregular and occasionally several of them seemed fused together into multinucleated, syncytial protoplasmic masses. In the cellular portions were numerous vacuolated areas which had been filled with fat. These resembled small cysts and have been described as oil cysts. Many of these were surrounded by giant cells which had fused together to engulf the vacuole. In addition to

the fat droplets and vacuoles, there were numerous clefts which had been occupied by fatty acid crystals. Several giant cells had engulfed some of these crystals. The lesion was relatively avascular. A few tiny capillaries could be made out, and occasional arterioles were seen. The majority of these latter were the seat of an intimal proliferation, and in many of them this had occluded the lumen. In the center of the tumor was a mass of necrotic fat containing numerous fatty acid crystals and large clumps of necrotizing polymorphonuclear leucocytes. Leucocytes and lymphocytes, with occasional eosinophilic leucocytes, were scattered throughout the peripheral zone.

From the disposition of the inflammatory cells it was seen that the central portion of necrotic fat was being invaded and would ultimately have been absorbed and replaced by fibroblasts and giant cells. This might have gone on to cicatrization. Occasionally, however, the central zone of necrotic fat may not be observed, but becomes liquefied and a cyst results, the

wall of which is made up of the compactly arranged fibroblasts and giant cells. In some instances calcium has been deposited.

Lee and Adair,<sup>1</sup> who first reported this lesion in this country, ascribe the exciting factor to trauma. According to Hadfield, direct and severe trauma was the exciting factor in about 40 per cent of the cases. In this instance no direct trauma had been sustained, but the friction between the skin of the breast and the corset was undoubtedly a chronic irritation and may be considered the exciting factor.

#### SUMMARY

An instance of traumatic fat necrosis of the breast is reported and described, and the histological structure outlined. The importance of recognition of this lesion and of differentiating it from a carcinoma is stressed.

<sup>1</sup> Lee and Adair. Traumatic fat necrosis of the breast *Ann. Surg.*, 80: 670, 1924.





OBSERVATIONS ON THE  
PATHOLOGICAL PHYSIOLOGY  
OF THE OMENTUM AND DUODENUM\*

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THE functional importance of any organ, appendage or membrane may be determined by observing the effect of its removal upon a group of like individuals. A less direct but more interesting method consists in a reflective consideration of the facts, so far as these are known, dealing with the phylogenetic rise of a species. Consider for a moment the anthropoids at about that time when hands were still used exclusively in locomotion and before the great economic advance which enabled two extremities to do the work of four. We know that the liberated front extremities became prehensile through evolutionary change and adaptation of the locomotor function, primitively in order that the individual might seek his food or safety in trees, and that the final elaboration of these members into the human hand was of singular help to man. So also, it should not be forgotten that the form and function of other structures in the anthropoids have undergone certain less direct, more subtle and often recessive and unfavorable changes coincident with and directly resulting from this epochal alteration in the locomotor habits of the race. It is axiomatic that no beneficial and fundamental change can be made in any mechanism without causing maladjustment in many subsidiary parts. There can be no great gain without some compensatory loss. We have heard much of the disabilities in us which are traceable to postural change. The gravitational pull upon the abdominal viscera, causing herniae and mechanical displacements, has been stressed. Less attention has been given to the study of visceral functional alteration or derangement. Such alteration

may be due not by any means alone to gravity but to the introduction of fundamental changes in the requirements of the individual. For example: the human appendix is the vestigial remnant of a once important organ that has atrophied, not because of gravity or posture, but in spite of it, and because no longer required. Form seems to be fundamentally secondary to function, and functional change, whether recessive or adaptive, is dependent upon the needs of the individual for protection and subsistence. The phylogenetic advantage which followed assumption of the upright posture, the coming of the human hand and intelligence, far outweighs the many disadvantages which have resulted, and actually enables us to sit in judgment on our own functional disabilities and to trace many of them to age-old structural change.

Little is known of the function of the human omentum. Very few critical studies have been made. Its absorptive and bactericidal powers have been described by Buxton and Torrey,<sup>1</sup> by Vaughan,<sup>2</sup> by Goldschmidt and Schloss<sup>3</sup> and others. These investigators failed to find that it possessed any automotive or ameboid characteristics, or a negative or positive chemotaxis. Hektoen and Reisman<sup>4</sup> speak of it as a sort of nervous heart in the abdominal cavity which keeps up an imperfect form of circulation, serving to transude plasma or lymph into the abdominal cavity and to absorb what is already there. Review of all the possibilities reveals to us, at least in man, two known functions only: the absorptive and the bactericidal. In the quadruped, on the other hand, the omentum lies in the

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†Dr. Draper died suddenly on January 26, 1931.

pendent portion of the abdominal cavity. Upon it falls much of the weight of the hollow abdominal viscera as well as some of the weight of the solid viscera. The belly wall, through adaptation to this weight supporting requirement, is reinforced with dense and powerful fascial planes which are as important to the welfare of the individual as is the ligamentum nuchae. Both of these structures in man have undergone the atrophy of disuse. The weight supported by the sling-like ventral wall of the quadruped bears directly upon the omentum and it is here in all probability that one of its most important functions finds expression. It is a fat-bearing labile cushion interposed between the mobile visceral peritoneum and the immobile parietal peritoneum. In addition, the deposition of excess fat in the omentum during the period of lush feeding serves not only as a storehouse but also as a thermal protection to the abdominal viscera in the cold and lean months.

The high absorptive power of the omentum has been demonstrated experimentally in laboratory animals of various types. Whether or not this same absorptive coefficient is present in man is debatable. Abstract reasoning would seem to indicate that the absorptive function in the quadruped would be considerably more important because of gravitation of fluids toward the ventral wall of the peritoneal cavity, where the omentum, in its capacity as a bilge pump, would be able to fully utilize its absorptive powers. In man this gravitation is toward the pelvic cavity, almost always out of reach of the omentum, and it is this fact which may explain the relatively high degree of resistance to infection exhibited by the pelvic peritoneum and the value of Fowler's position in peritonitis, in both male and female. The ability of the omentum to absorb is due to its rich blood supply as compared with that of other peritoneal surfaces. But is this very absorption a protection or a detriment? It may be argued, and very reasonably, that this blood supply

accounts not only for its absorptive powers but also explains its protective value in the presence of peritoneal infection, for its placement, now known to be accidental, near the site of infection supplies an added source of leucocytes and immune bodies. This is undoubtedly true, and especially so in the quadruped where there is less interference with the venous return in the non-muscularized but mechanically supported omental tissue. In the upright posture of man the venous return is without support, muscular, valvular or mechanical, excepting as feebly exerted by changes in intra-abdominal pressure and by peristaltic motion. There is therefore even in the healthy omental tissue a constant tendency toward chronic passive congestion and subinfection. The presence of chronic intraperitoneal infection with resulting hyperemia in the omentum may easily lead to venous engorgement and varicosity, finally ending in a deficient rather than in an efficient blood supply; in contracture and sclerosis and in ultimate damage to the structure.

It appears to be generally conceded that the omentum has no inherent powers of mobility, or positive or negative chemotaxis. On the other hand, clinical observations upon the behavior of the freely mobile gut in chronic or subacute localized peritonitis have led us to believe that the visceral peritoneum may exhibit a marked selectivity or attraction, which may be more than accidental, toward an inflammatory area. We have repeatedly observed, roentgenologically, the dislocation of the terminal part of the ileum into the right upper quadrant in the presence of operatively demonstrated lesions of that area, and we have come to rely upon this ileac migration without fixation as one of the striking bits of evidence in the chain which must be pieced together before an accurate diagnosis is reached. Similarly the persistent finding of the major portion of a long sigmoid in the pelvis is not necessarily indicative of dislocating adhesions in the pelvis, al-

though these are sometimes found. It frequently indicates a pelvic peritonitis, especially in the female, and although the clinical picture is much the same as in the case of perisigmoidal adhesions the surgical indications may be quite different. It is noteworthy that the omentum is not found with any regularity at the site of these peritoneal inflammations. When it is so found, incorporated within the defensive wall, the symptoms of toxic absorption tend to be exaggerated over and above the possible merits of the pathological condition, unless the character of the infection is of such nature as to cause a protective thrombosis of the omental vessels. While in this paper we are not attempting to deal with the acute surgical accidents of the peritoneal cavity it is pertinent to inquire into the possible bearing of the absorptive ability of the omentum upon the toxic and usually fatal syndrome of generalized peritonitis. The protective thrombosis of the omental veins may occur too late to prevent an overwhelming systemic bacterial invasion through the omental pathway.

Investigators who have devoted much attention to experimental surgery in the lower animals are aware of the very high mortality which follows generalized peritonitis. It would seem that this fact militates against the idea that the great omentum, here so highly developed, has an important protective value against peritonitis, and that on the contrary because of its high absorptive coefficient by way of the blood stream it may lead to a systemic diffusion of the infection. We believe that the true function of the omentum has been misunderstood. Its function in the quadruped is to fulfill biological needs. It is not placed in the quadruped belly primarily to prevent or wall off accidental perforations or to absorb great quantities of bacteria or pus, but rather as an integral part of the animal's ordinary and daily physiological habits. To assume that the *human* omentum has developed characteristics transcending the

humble biological traits of the quadruped omentum is a homocentric notion, about as rational as to assume that fish are placed in the sea for us to eat.

During the past five years we have studied with more than casual intent the great variations in omental size, form and structure encountered in all varieties of human beings. Much of this variation is undoubtedly associated with postnatal development. Some of it, however, can scarcely be accounted for in this manner and it is apparent that the size and formation of the omentum are as dependent upon prenatal growth impulses as upon postnatal growth changes. The entire process is subject to the Mendelian law. Certain individuals are born with a relatively small and fragmentary omentum, so small indeed that it is impossible to conceive how its function as a migratory, protectively vascularized structure could be anything but minimal. In other individuals the omentum is of relatively great size, found in all corners of the peritoneal cavity, and reaching deep into the pelvis. Is it not proper to pose this question: If the omentum has a definite and necessary function, adapted to the welfare of the individual, should it not be reasonably consistent in its form and distribution? In the cat the great omentum averages about 400 sq. cm. in size. In the human the size varies much more than in the quadruped and the structure is frequently much smaller than that of a cat. It would seem, therefore, that in the quadruped, as already intimated, it serves a purpose which in the human it fails to serve, except in an irregular and inefficient manner. If the omentum is undergoing important but very slow recessive change, because its physiologic or labile properties are not capable of being called into play in the upright posture, it is reasonable to ask why it persists at all. We have not attempted to deny to it all of its primeval physiological qualities as exemplified in the quadruped, and it is undoubtedly still somewhat useful in man. In the pres-

ence of incomplete functional loss of a part the period of adaptive change must extend over many thousands of years, and it is evident that the final stage of evolution in this structure has not yet been reached.

In a previous paper<sup>10</sup> we have discussed at some length the probabilities as to the aberrant character of the embryonic development of the omentum and have stated that in some way it was associated with irregularity of growth impulses which led to abnormal placements of the great omentum upon the colon during its rotation. The development of the peritoneal cavity, of its folds, its mesenteries, its plicae, its recesses, is perhaps as complex as is the development of the structures of the central nervous system, and it undergoes far more variations in its final form. The finished product is almost impossible to visualize, but the fact remains that this complex embryological feat is completed in a fairly orderly manner. Not so with the omentum. The end-stage of its development indicates that its beginning must have been as disorderly as the final result. The growth impulses responsible for its delamination are aberrant and subject to suppression and recession, and this perhaps because nature is becoming doubtful as to just what the terminal product is to be and what its function is to comprise. And so we find in the nearly completed embryo as well as in the newly born infant strands and veil-like attenuations of this dubious structure abnormally inserted upon the gut, if not actually arising from atypical positions in the mesogastrium. In the quadruped our observations indicate that stability in omental form and size is to be expected. In the human, on the other hand, such stability has been lost, owing to the atrophy of disuse.

The great omentum is a composite four-layered structure derived from the posterior mesogastrium. Its posterior layers fuse with the transverse mesocolon. The anterior mesogastrium subsequently gives rise to the lesser omentum and from its

right border, known as the hepatoduodenal ligament, there occasionally arise abnormal extensions which may become incorporated with the great omentum or may remain entirely separate from it. In the latter case such a separate band may find insertion upon the ascending colon and sometimes upon the terminal ileum. The relationship of such bands to the great omentum cannot always be determined through study of adult pathological morphology. They often resemble omental tissue and may have arisen from the omental anlagen. As a rule they produce certain types of colonic deformity which when recognized should direct the observer's attention not only to possible disturbance of colonic function but to that of the duodenum as well. In early life these structures usually escape observation, to be discovered later only as a result of their gradual contraction and provocation of symptoms. Their origin close upon the oral, or proximal, duodenum is a very serious matter even early in life, for their abnormal insertion upon the colon often results in damaging duodenal pressure from the added weight of the loaded colon in the upright posture. Certain of these bands cross the third portion of the duodenum as well, and may be seen to fuse with the transverse mesocolon. It should be remembered here that the transverse mesocolon plays an important part in the formation of the great omentum by fusing with its two posterior layers. In those cases where gross portions of the great omentum proper are to be found crossing and compressing the ascending colon, the stress exerted by the contracting omental tissue may be transmitted to the third portion of the duodenum through the transverse mesocolon. Certain obscure malpositions of the left transverse colon may be caused by congenital contractures of the left transverse mesocolon before the final fusion with the great omentum. Such a contracture tends to pull the left transverse colon upward and to the right into a position posterior to the stomach and adjacent to the duodenal fossa (Fig. 1).

Interference with the free functional behavior of the duodenum is a very serious matter. Imboden,<sup>5</sup> Kellogg,<sup>6</sup> Friedenwald,<sup>7</sup> the writers<sup>8</sup> and others have recently commented upon this. The rapid lethal outcome of complete duodenal obstruction with tetany and convulsions is a dramatic expression of the potential dangers lurking within this most highly specialized part of the alimentary canal, as was pointed out by the senior author twenty years ago.<sup>9</sup> It is logical, therefore, that partial obstructions here should result in serious systemic disorders. The mechanism by which the duodenal disturbance in function is brought about may not be at all clear. The supposed scissor action of the superior mesenteric artery has been a moot matter for the past twenty years. It is not always possible to demonstrate localized organic defects in or about the duodenum itself, either roentgenologically or surgically. Aside from the purely reflex phenomena, characterized either by regurgitation or dilatation and which are the result of lesions elsewhere in the canal, there is the problem of the influence of direct traction and compression upon the duodenum, transmitted in abnormal directions through the mesocolon. The existence of such forces cannot be presupposed unless there can be demonstrated roentgenologically the colonic dysmorphism more or less characteristic of this type of omental and mesocolic aberration. The acquisition of secondary adhesive structures about a duodenum which is chronically compressed by a congenital band is to be expected. Whatever be the source or the type of pressure, its effect upon the duodenal epithelium is to cause the elaboration of highly toxic products which secondarily affect liver function, resulting in the most serious and, dependent upon the degree of pressure obstruction, the most variable symptoms. It is our belief that certain neurological and metabolic disturbances of the so-called allergic type and of very grave significance find their true origin in these partial pressure obstructions of the duodenum.

The rôle of the omentum and of its mesogastric anlagen in producing these pathological disturbances in hepatic, pan-



FIG. 1.

creatic and duodenal physiology is gradually becoming clarified. The colonic and terminal ileac disturbances of omental origin have been more easily discovered and in the past we have been tempted to believe that the duodenal disturbances were in large part reflex from these. Such reflex disturbances are not to be denied. The relative incidence of direct and indirect interferences with duodenal physiology and their degree of concurrent activity are not yet known. Certain it is that omentectomy and restoration of more adequate colonic and duodenal function by decompression and mobilization have been of great practical value as a surgical procedure.<sup>10</sup> Indeed we have often thought, and not without reason, that the benefit accruing after the removal of a colon of the type described by Ewing<sup>11</sup> as *not* beyond the hope of conservation has been due to the relief of pressure-producing

mesocolic traction upon the duodenum, and that release of such traction could have been accomplished without colectomy.

Omentectomy is looked upon in general as an extremely hazardous procedure, but this has not been our experience. In 200 odd cases in which it has been done by us there has not been a single death directly attributable to it, there having been 3 deaths from pneumonia and 2 from perforation of an attenuated colonic segment which should have been resected rather than liberated. Finally, if owing to the upright posture the omentum has now a diminished capacity to pump the peritoneal cavity and to cushion the gut mechanically, and also is practically devoid of the protective qualities generally attributed to it, this recessive structure should receive the same surgical consideration accorded to any tissue which has become useless and menacing through a combination of disuse and disease.

#### SUMMARY

1. The function of the quadruped omentum transcends that of the biped. Change of posture and consequent decrease of physiological function have resulted in an atrophy of disuse.

2. It has not been proved, either in the quadruped or biped, that the omentum has any outstanding protective function. Its mobility is really lability and in the quadruped it is the bilge pump of the peritoneal cavity.

3. The high absorptive coefficient of omental tissue is due to extreme vascularity and elasticity. In the biped this function is diminished, owing to circulatory difficulties incident to the upright posture and to failure to reach the lowest part of the peritoneal cavity.

4. In the quadruped resistance to abdominal infection *may be* inherent in the omentum. In the biped it has devolved largely upon the pelvic peritoneum.

5. Embryologically the great omentum arises from the posterior mesogastrium, the posterior or inferior layers of which

become fused with the transverse mesocolon.

6. Abnormal bands arising from the anterior mesogastrium and inserting upon the right colon may compress the duodenum. Abnormal stresses induced by atypical placements of the great omentum upon the colon are transmitted to the duodenum through the transverse mesocolon.

7. These omental aberrations which are heritable, being subject to the Mendelian law, are due to abnormal growth impulses consistent with recessive functional characteristics.

8. Interference with duodenal function is of grave importance. This may be reflex or due to mechanical factors associated with abnormal omental and mesocolic development. Whatever the source, the resultant partial duodenal obstruction causes the elaboration of toxic products which give rise to metabolic and neurological disturbances of grave nature.

9. Omentectomy is indicated when the omentum is definitely diseased or malformed.

#### DISCUSSION

DR. WILLY MEYER: In one statement, it is said: "The omentum is devoid of all automotive power." I cannot agree with this dictum. For many years surgeons were used to calling the omentum the "policeman" of the abdominal cavity, because we were always finding it protecting some of the important abdominal organs in case of injury, inflammation and so forth. Now, we find it protecting the liver or the stomach; then the colon, or other portions of the intestinal tract, even the retrocecal appendix, and so on. If we meet a duodenal ulcer in a place 2 in. below the pylorus attached to the lower surface of the liver, we may find it covered and protected by the omentum, although this has its start at the major curvature of the stomach. Fortunately, in most cases, it is so well developed, that it can reach the place of danger in its wanderings.

DR. JOHNSON (*closing*): I do not feel at all qualified to answer Dr. Meyer's discussion, not being a surgeon, and so I will allow that par-

ticular phase of surgery to pass by. The question as to whether the omentum is the abdominal "policeman" is one which we have been struggling with for a good many years. There is no doubt that, in the abdomen, owing to its placement over various organs, the omentum does fulfill an important protective function biological in nature, and if the structure be damaged, alteration in health will result. It has not been proved, however, that it either possesses or exerts any specific antibacterial powers. We have said that it is devoid of autonomic mobility, that its migration is as much accidental as selective, and that it has no greater motile power than other movable abdominal organs toward the site of inflammatory lesions. No one knows, no one has proved, what the automotive power of the

omentum may be. Experimental work which has so far been done in animals has been negative in this respect, but it is stirring up interest in the subject, so that I feel sure other investigators will eventually settle the question definitely. In the original or quadruped state of the human animal, the omentum served a biological or a physiological purpose by reason of its position in the abdominal cavity. Its protective qualities should be, and are, dependent upon its physiological importance and activity, and in the human these have become minimized through disuse incident to postural change. We cannot admit that its primary purpose or function is, or ever has been, to protect the individual against intra-abdominal accidents; that biological failure can possibly result in physiological benefit.

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# URINARY TRACT MANIFESTATIONS IN TRAUMATIC MYELITIS

DUE TO FRACTURE OF SPINE WITH PARTICULAR REFERENCE TO MANAGEMENT\*

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IT is a well known fact that the urinary tract changes are of paramount importance in traumatic myelitis, particularly urinary infection. Déjérine<sup>2</sup> (1914), Frazier<sup>5</sup> (1918), Oppenheim<sup>10</sup> (1923) and others have considered them in diseases of the spinal cord. The contributions of Thompson-Walker<sup>12</sup> (1917), Head and Riddoch<sup>7</sup> (1917), Fearnside<sup>4</sup> (1917), Riddoch<sup>7</sup> (1917), Plaggemeyer<sup>11</sup> (1919), O'Connor<sup>9</sup> (1928), Elsberg<sup>3</sup> (1928) and others are very instructive and valuable in this connection.

## URINARY DISTURBANCES (NEUROLOGICAL)

Neurological dysfunction of the bladder in lesions of the cord may express itself in (1) retention and (2) incontinence. Incontinence may be one of three types: (1) interrupted incontinence (automatic bladder), (2) overflow incontinence (paradoxical bladder), (3) complete incontinence (paralytic bladder).

*Retention:* Retention may be caused by (1) a break in the path carrying painful stimuli to the cerebrum, (2) tonic contraction of the internal sphincter, (3) tonic contraction of the external sphincter and inability of the individual to relax the same.

*Automatic Bladder (Interrupted Incontinence):* In automatic bladder the sphincters are in tonic contraction but there is associated hypertonicity of the bladder wall musculature so that as soon as a certain set amount of urine collects in the organ the detrusor contracts and overcomes the sphincters. In patients suffering from

this condition the urine spurts out at intervals. The amount of urine necessary to stimulate the bladder wall musculature may be different in the same individual at various periods in his illness.

*Paradoxical Bladder (Overflow Incontinence):* Overflow incontinence is associated with atonia of the bladder wall although the sphincters are in tone. As soon as there is an increase in the intravesical pressure (due to accumulating urine) to a degree sufficient to overcome the sphincter tone a certain amount of urine escapes. In overflow bladder then, the organ is distended at all times.

*Paralytic Bladder (Complete Incontinence):* Complete incontinence is caused by atony and paralysis of the sphincters and the bladder musculature and accordingly the latter is empty at all times. Paralytic bladder may be seen in extreme shock where the reflexes of the body in general are impaired. It is also seen in traumatic myelitis in its later stages. When the mucosa of the bladder wall and the part in the urethra surrounded by the sphincters become destroyed, thus also destroying the nerve supply, complete incontinence obtains. The reason is evident. The sensory limb of the reflex vesical arc being abolished, the reflex act of micturition becomes impossible.

*Combined Forms of Incontinence:* Combined forms of incontinence are also very frequent and the transition from one form to the other gradual. Thus a patient may have periods of retention alternating with

\* This is one of a series of papers on traumatic myelitis due to fracture of the spine (see References). Most of the material was collected at the University Hospital, Ann Arbor, Mich. All case numbers unless otherwise indicated belong to the Ann Arbor group. The series from the University of Michigan comprise 72 cases to which we have added 10 cases from the Receiving Hospital, Detroit, Mich. We thank Professors Carl D. Camp and M. M. Peet for their interest in this work. We also thank Dr. E. T. Olsen, Superintendent of the Receiving Hospital.

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automatism while the latter is being established, or an automatic bladder may eventuate in complete incontinence (due to infection and destruction of the vesical mucosa).

In traumatic myelitis the vesical changes may express themselves in any of these ways but the first manifestation is invariably retention (Thompson-Walker,<sup>12</sup> 1917, Plaggemeyer,<sup>11</sup> 1919) with the possible exception of patients in shock. Later overflow incontinence, interrupted incontinence or normalcy may ensue. The bladder dysfunction in these cases is due to (1) concussion of the cord, (2) destruction of the vesical center (conus lesions), and (3) destruction of the cord above this level.

*Urinary Dysfunction in Cases with Concussion of the Cord:* In a group of cases after cord injury the dysfunction lasts only a few days. This may be due to a concussion of the cord or a subsiding edema at the level of injury. In the present series there are several examples of this type (see Table 1).

*Urinary Dysfunction in Cases with Conus Lesions:* In this group the first urinary manifestation is again retention. With the freeing of the peripheral vesical apparatus from its central connections the organ is at the mercy of the sympathetic system (Thompson-Walker,<sup>12</sup> 1917). Axon reflexes must be very important in this connection. Thus reflex arcs are probably established with afferent vesical fibers synapsing with efferent ones in the hypogastric ganglion. The development of an automatic bladder is possible in these cases and this is explained on the basis that the sympathetic system assumes the nervous control of the organ. In one of our cases with a lesion of the conus there was complete retention followed by interrupted incontinence and at times the characteristics of overflow bladder.

*Urinary Dysfunction in Cases with Lesion above the Conus:* When the cord is injured above the sacral level the vesical dysfunction is brought about by an interruption of the reflex path to higher centers and

from the latter to the vesical center. In the majority of the reported group there was retention and a history of catheterization. Very few in this series gave a history of interrupted incontinence almost from the beginning. In these cases automatism is most probably effected through the spinal cord rather than the peripheral sympathetic ganglia.

The bladder dysfunction may be the outstanding symptom of traumatic myelitis. Frazier (1918) describes a patient with a cervical lesion whose main disability was urinary and rectal paresis. But as a rule there are associated motor or sensory changes or both.

In another group the absence of bladder dysfunction is remarkable notwithstanding signs of serious cord involvement. For instance, T. L. T. (163952) was in an automobile accident September, 1925. Subsequently he was paralyzed in both upper and lower extremities. By December, 1925, he was able to walk. At no time were there any sensory changes. Examination on March 10, 1927, showed a bilateral spastic gait with increased tendon reflexes and bilateral Babinski sign. There was much atrophy of the shoulder girdle and the upper extremities. He showed no urinary dysfunction at any time, which can be explained on the basis that the reflex vesical paths were left intact, notwithstanding the central softening of the cord in the cervical region causing a destruction of the central grey matter and partial destruction of the pyramidal tracts. In another patient (144883) there was paralysis from the neck down following a diving accident in August, 1925. Paralysis improved until he was able to walk and examination in May, 1927 showed signs of cord involvement of a hematomyelic nature. There were no vesical or rectal disturbances in his case. F. L. R. (174613) entered the hospital with marked spastic paraplegia and inability to walk after an automobile accident twenty months before admission. The patient at no time had

sphincter disturbances. It is interesting to note that all the cases cited here had lesions of the cervical cord. In the cervical region there being more cord substance and more room in the vertebral canal a selective involvement of nervous tissue is possible. The area of least resistance is, of course, the central grey matter and its surrounding tissue. However, E. M. L. (135388) who had a compression fracture of the ninth thoracic vertebra with definite sensory and motor changes, also had no urinary or rectal disturbances at any time. The post-mortem examination of the cord showed liquefaction necrosis and much tract degeneration at the level of injury.

With partial severance and destruction of the spinal cord associated with urinary disturbances there is hope for amelioration or complete recovery. The mechanism of recovery is dependent upon (1) subsidence of pressure against ascending and descending paths, (2) in the case the vesical ascending and descending paths are destroyed the possibility of conveyance of impulses through other paths. In the majority of the group reported recovery took place within two months. In 1 case there was fair control within thirteen months after injury. The following tabulation gives more accurate data on this phase of the subject:

RECOVERY FROM BLADDER DYSFUNCTION

Case No	Time	Case No.	Time
208354	About 2 days	199267	About 3 weeks
181114	About 2 days	151579	About 5 weeks
H8504*	About 2 days	155076	About 7 weeks
180751	About 3 days	165089	About 6 weeks
195728	About 10 days	142972	About 2 months
171717	About 2 weeks	131165	About 3 months
211268	About 4 days	128741	About 8 months
192880	About 3 weeks	144383	About 13 months

\* From the records of the Receiving Hospital.

#### URINARY INFECTION AND ITS MANAGEMENT

Urinary infection is one of the most dreaded of the complications of traumatic myelitis. Its onset may be surprisingly rapid. In certain cases it progresses rapidly with consequent pyelonephritis (fulminat-

ing type). Its clinical manifestations are severe and if not properly treated patients succumb. Thompson-Walker<sup>12</sup> (1917) states that over 90 per cent of spinal injury cases during the War coming to the Star and Garter Hospital had severe urinary infection. In another hospital, of 339 cases of spinal injury 160 patients died from urinary infection.

The condition usually follows catheterization and faulty treatment of the urinary tract after instrumentation. In the present series we have had 7 patients having urinary tract infection, 4 of whom came to autopsy. Six in this group gave a history of catheterization. The remaining one (a female) had incontinence for about two years and died of acute tonsillitis. Autopsy showed advanced urinary tract infection with multiple abscesses in both kidneys. In her case the infection may have ascended through the urethra into the bladder and on up. No history of instrumentation could be elicited. That every catheterized case of traumatic myelitis will develop pyelonephritis is not true. But it is a fact that such patients are potentially infected and unless much care be taken in their proper treatment a grave outcome is to be expected. It is unfortunately true that even with proper care they may develop fulminating pyelonephritis with consequent death.

Fulminating pyelonephritis was the direct cause of death in 3 patients. I. M. (158638) died seven weeks after injury to the back. Her clinical course was characterized by chills and septic temperature. Urine grossly showed pus. Neurological examination was indicative of transverse myelitis at the level of the twelfth dorsal segment. D. L. (148094) died thirteen weeks after injury. The course of his case was also typical of urinary tract infection, but a few days before death was complicated by terminal bronchopneumonia. At autopsy the kidneys showed far advanced pyelonephritis. There was also ureteritis and cystitis. H. A. H. (127420) died sixteen days after injury. He also showed the picture of fulminating pyelonephritis. The cystitis in

these cases is very severe and often of the hemorrhagic type.

With the proper treatment certain cases of acute urinary infection become quiescent. They either get well or advance into the chronic state with acute exacerbations from time to time. The exacerbations are undoubtedly caused by poor drainage. For instance, in 1 case (216557) poor drainage for a day or two would always cause an increase in temperature and chill.

The care of the urinary tract in traumatic myelitis is a serious problem. In the presence of retention there are 4 possibilities: (1) emptying of the bladder by suprapubic pressure; (2) catheterization at definite intervals; (3) inlying catheter (catheter à demeure); (4) suprapubic cystotomy.

Crédéing would be ideal if it worked in every case. There is practically no danger of rupturing the organ by suprapubic pressure unless there is disease of its walls.\* The sphincters are overcome much before enough force is used to injure the vesical musculature. In the present series only 3 cases could be treated by crédéing alone. It is true that by such a procedure complete evacuation of the organ is not insured and if there is a history of catheterization suprapubic pressure should never be tried. In 1 case in this series we think such treatment was the cause of fulminating pyelonephritis. H. A. H. (127420) had been catheterized once. Instead of being placed on continuous drainage or catheterized at set intervals the bladder was allowed to distend and he was crédéed. In the course of a few days he developed a septic temperature and chills. Finally he was placed on an inlying catheter but it was too late. In about sixteen days he died. The valuable time lost in crédéing this patient allowed

the infection to ascend in the presence of a distended organ, for suprapubic pressure does not insure complete evacuation except in cases with very favorable anatomy. To make the irony of fate worse his spinal condition was much better before death.

Catheterization at definite intervals along with irrigation of the bladder with mild antiseptic solutions, acids or alkali as may be indicated is a good and accepted form of treatment.<sup>3</sup>

Continuous drainage of the bladder through an inlying catheter is a good form of treatment and is usually successful. Fluids are forced and the patient given some urinary antiseptic by mouth (sodium acid phosphate and urotropine). The bladder is irrigated with mild antiseptic solutions daily. With this treatment the septic temperature of more than 1 case has become normal. In the male the scrotum is also supported by some appropriate means. Urethritis is at times very annoying but this has never been of such proportions as to prohibit this method of treatment. The catheter is changed twice a week.

Thompson-Walker<sup>12</sup> (1917) discusses the advisability of prophylactic suprapubic cystotomy in all cases of traumatic myelitis with urinary dysfunction. If the epididymis becomes involved this operation may be the only method to follow. In the present series we have had no cases with scrotal involvement, although we are cognizant of the fact that such a complication does occur at the frequency of about 10 per cent in all catheterized patients.<sup>12</sup>

In cases with inlying catheter the latter may be left out at intervals to note if there is a return in function or if an automatic bladder has developed. If partial return of function is present it is preferable to study the bladder for a few days and note the amount of residual, if any. In some cases the organ may have to be catheterized to effect complete evacuation at least once daily.

*In conclusion, emptying of the bladder by suprapubic pressure should be tried in every case with no history of catheteriza-*

\* One such case came to our attention at the University Hospital, Ann Arbor, Mich. The patient had syphilitic cord disease with retention. On suprapubic pressure the tumor mass suddenly disappeared and soon after the patient began complaining of lower abdominal pain. In the course of a few hours he showed signs of peritonitis and was operated on. There was a longitudinal tear in the dome of the bladder. Autopsy showed diphtheritic involvement of the bladder wall at the site of rupture.

tion. The urine should be examined frequently for the presence of infection. If it is present the only way to treat the case effectively is by drainage: inlying catheter or catheterization at definite intervals. If there is a history of instrumentation continuous drainage should be instituted at once.

#### SUMMARY AND CONCLUSIONS

1. The first manifestation of urinary dysfunction in traumatic myelitis is retention. Constant dribbling is never seen in the beginning (unless the patient is in extreme shock).

2. Severe injury to the cord need not always be associated with urinary dysfunction. Several examples of this type are given in the text.

3. The evolution of urinary disturbances in traumatic myelitis is usually as follows: (1) retention or retention with overflow;

(2) a period of retention with active incontinence or retention alternating with spells of voluntary micturition; (3) active incontinence (automatic bladder) or complete recovery of function; (4) in cases with active incontinence with urinary infection there may develop a complete incontinence (paralytic bladder) or constant dribbling.

4. The period of retention in this series has been from three to five weeks on the average. In this connection it is important to note that extreme distension of the bladder enhances return of function or the production of automatic bladder.

5. Urinary infection is serious. In a case with distension as soon as the diagnosis of infected bladder is made the patient should either be placed on continuous drainage or catheterized at frequent and regular intervals. The administration of urinary antiseptics and mild irrigation of the bladder are also indicated.

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## SUPPURATIVE SUBCUTANEOUS AND SUBFASCIAL GONOCOCCUS INFECTIONS\*

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THE following 3 cases illustrate unusual types of suppurative lesions due to the gonococcus.

CASE I. Male, aged fifty-three, was admitted to the Bell Memorial Hospital of the University of Kansas on November 15, 1929 with a draining sinus below the left great trochanter. A history of gonorrheal urethritis about six months before was obtained from his family doctor. Thirteen weeks before admission infection started in the region of the left trochanter, following a slight injury. About five weeks after injury the infection was incised and drained. The wound did not heal and persisted as a sinus, extending beneath the deep fascia just below the trochanter. Repeated smears from this sinus showed many gram negative, intracellular diplococci, morphologically characteristic of the gonococcus. The prostate was enlarged and tender. He was treated for a time with hot packs, permanganate, acriflavine and mercurochrome irrigations without improvement. At operation an extensive narrow abscess tract with granulating walls was found extending downward from the trochanter beneath the fascia lata. Healing was slow and a slight discharge of pus persisted. A second operation one month later showed that the infection had burrowed beneath the deep fascia two-thirds of the distance from the trochanter to the knee. A third operation was done four months after the first and the sinus tract was found extending further down the thigh. At the end of six months there was a still further extension downward as far as the femoral condyle. As the infection progressed downward beneath the deep fascia, the incised wounds above gradually healed. All blood cultures were negative. At times he had a fever as high as 101° and 102°F. He left the hospital after six months with a persisting sinus just above the left knee at the site of the last operation. Several weeks later his family doctor reported his sinuses healed.

This subfascial infection persisted for more than a year, during which time the patient

almost died from what was apparently cardiac collapse. Disabling contractures as a result of disuse and faulty posture in bed persisted for more than a year after healing of the infection.

CASE II. White male, aged thirty-two, was admitted to the hospital on September 24, 1929 with an active gonorrheal urethritis of three weeks' duration. Five days before admission he developed painful finger and wrist joints. His right hand and wrist became swollen and the day before admission red streaks were noted extending up his forearm. Five days after admission it was evident that an abscess had developed on the dorsum of the left index finger near the base. This was incised and pus obtained. Five days later a large abscess on the ulnar side of the right wrist was incised and drained. Both abscesses appeared superficial and no connection with the tendon sheaths was found. Gram negative intracellular diplococci were obtained from both abscesses which were morphologically identical with the gonococcus. These infections all healed within two months without any stiffness or limitation of motion of fingers or wrist.

CASE III. White male, aged twenty-three, was admitted to the Hospital on October 20, 1930 and was discharged on November 20, 1930. He gave a history of gonorrheal urethritis three years ago. One year ago he bruised his right buttocks, which later became swollen, discharged pus, and formed an ulcer. With local treatment this closed in two months but reopened in a few days. It has healed and opened several times during the past year. Six months ago he had a recurrence of the gonorrheal urethritis. About two months ago the last abscess formed and was still unhealed when he was admitted to the hospital.

Examination revealed gram negative, intracellular organisms in the prostatic pus characteristic of gonococci. The same type of intracellular organisms was found in smears from the ulcerating area on the buttocks.

The infected area on the buttocks involved only the skin and subcutaneous tissues. There

\* From the Department of Surgery, University of Kansas. Submitted for publication January 26, 1931.

was scarring over an area 3 cm. by 5 cm. with some pigmentation.

There was no history of syphilis and the Wassermann test was negative. The patient was treated with aolan injections three times each week for three weeks. He also had two x-ray exposures. The lesions have now been healed for about one month. He still has chronic prostatitis.

#### DISCUSSION

No tissue of the body can claim immunity from gonococcus infection. In addition to infection of the genito-urinary tract, it may cause arthritis, bursitis, tenosynovitis, endocarditis, meningitis, pyelitis, proctitis, pleuritis, neuritis, myositis, pyemia, abscess of lung or kidney and inflammation of the bone, eye, nose and skin. Certain hyperkeratoses of the genitals, palms of the hands and soles of the feet are due to the gonococcus. It is not very uncommon to find petechial hemorrhages and nodular erythema in cases of general gonococcal septicemia. Gonococcus infection is no longer considered a localized malady, but a general systemic disease with varied localized manifestations. Infection of bursae and synovia with adjacent periarticular tissue is the commonest result of dissemination of the gonococcus. The mucous membrane of the urethra and the conjunctivae is the commonest location for the primary infection. Complications of the primary infection usually occur within three to five weeks after the onset and commonly when the initial disease seems to be subsiding.

Lawson and Smithwick<sup>1</sup> discuss gonorrheal infection in postoperative abdominal wounds and report 2 cases. One infection followed operation for acute salpingitis, and the other an exploration at which no definite disease was found. The second patient had an active gonococcal endocervicitis and vaginitis. This wound infection may have come from the normal appearing tubes or as an indirect infection from the genitalia. Kingsbury<sup>2</sup> reports an infection in an abrasion near the elbow

resulting in an ulcer with undermined edges and sloughing base. Stephens<sup>3</sup> describes a gonococcus infection occurring in a sloughing ulcer resulting from a hot hypodermoclysis solution. Multiple subcutaneous gonococcus abscesses are reported by Kirmse.<sup>4</sup> He states that only 20 such cases were on record previous to 1921. In a girl seventeen years of age with a gonorrheal vaginitis, Dufour<sup>5</sup> incised a gonococcal abscess on the dorsum of the foot. He describes a similar subcutaneous abscess of the arm in a woman, aged twenty-six. From both of these cases the gonococcus was cultured. Other authors have described subcutaneous abscesses,<sup>6,7,8</sup> hemorrhagic purpura,<sup>9</sup> percutaneous infection in infants,<sup>10</sup> cutaneous hemorrhages and ulcers,<sup>11</sup> intramuscular abscesses,<sup>12</sup> and suppurative mastitis<sup>13</sup> due to the gonococcus. Dwyer<sup>14</sup> described a fatal case of acute gonococcal septicemia and endocarditis in a child twenty-three months of age in which there developed a superficial abscess in the lumbosacral region. Culture made from the abscess grew the gonococcus.

Our case of subfascial infection is interesting because of its extent and marked chronicity. We do not find a similar case reported. The source of this subfascial infection may have originated in the bursa over the trochanter, but this is not definitely proved. This case is a striking illustration of the progressive nature of such infections and prolonged disability that may result.

The second case is typical of other reported cases of subcutaneous abscess due to the gonococcus. The source here may have been in the tendon sheath, although such localization was not evident and no disability resulted due to tendon limitation of motion.

The third case is an example of the marked chronicity of gonococcal infections in and beneath the skin.

#### CONCLUSIONS

1. Three cases of metastatic gonococcus



infection are here reported. While cultures of the gonococcus were not obtained in these 3 cases, the history, clinical findings and microscopic study of the organisms seemed sufficient to warrant a positive diagnosis.

2. A study of metastatic infections due to this organism emphasizes the now generally accepted opinion that gonorrhea is not a localized, but a general, disease

that may manifest itself in almost any tissue of the body.

3. Slowly healing ulcers, unexplained persistent sinuses, and indolent healing wounds should make one suspicious of the possibility of infection by the gonococcus.

4. In the management of the treatment, silver preparations have seemed to yield the best results after prompt surgical intervention for points of abscess formation.

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## SCROTAL DRESSING HOLDER\*

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AN ordinary bicycle pants guard makes an ideal dressing holder for the male patient. A towel is draped around the scrotum and penis and the pants guard holds the towel snugly around the base of the scrotum. Thus these organs are held up and out of the way during a perineal or rectal operation and con-



FIG. 1.

around the scrotum and penis and the pants guard holds the towel snugly around the field of operation is prevented.

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# A STUDY OF THE EFFECT OF ACIDS AND ALKALIS

## ON GASTRIC MUSCLE STRIPS IN THE RABBIT\*

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ONE of the most interesting phases of gastric physiology is the behavior of the stomach muscle under conditions such as are observed with muscle strip preparations. Our knowledge of gastric function may be broadly divided into that governing the secretion, and that vitally concerned with the motor function of the stomach.

The latter subject has been approached from many angles. The clinician estimates it by the degree of chymification of food, by the evacuation time, with a test-load, and by the gross appearance of peristalsis as revealed by x-ray examination. The physiologist has not been content with these rather gross methods of approach. He has attempted by animal experimentation, by the examination of viscera under direct vision, by balloons which have been placed in the stomach, and finally by the behavior of isolated muscle strips, to obtain information on the complex mechanism which so remarkably reduces food to chyme.

In a recent study, Thomas, Eads, and one of the authors, observed the action of the antrum and duodenum in order to determine the sequence of events which occur in the normal human subject, with balloons fluoroscopically controlled and placed in these organs. The information which this study revealed was of importance in estimating the sequence of events which occurred in that segment of the digestive tract. The rhythmicity and power of the antrum musculature are scarcely realized unless they are observed in this way. The natural question which arises is: What determines this rhythmicity, and what are the factors which are concerned in its evaluation? This problem brought us into direct contact with some of the recent work on the excised musculature.

The normal movements of the stomach in situ have been described by M'Crea, M'Swiney, Morison and Stopford,<sup>1</sup> and the literature is reviewed in their paper. The normal movements of the surviving strips of the stomach were first investigated by Sick and Tedesco<sup>2</sup> who found that the movements of the strips and of the same parts of the complete stomach were identical.

Alvarez<sup>3</sup> found from a similar study of the excised strips of the stomachs of rabbits, cats, dogs, and man, that each region had a characteristic type of movement, and that the rate of contraction of the strips varied inversely as the distance from the cardia. Shultz<sup>4</sup> observed the action of the excised stomachs of dogs after the injection of drugs prior to the removal of the organ. The studies of Smith<sup>5</sup> on the action of the surviving muscle strips of the stomachs of guinea pigs, cats, rabbits, dogs and man, are complete. Hecht<sup>6</sup> studied the action of atropine on the complete surviving stomach of the rabbit, and Texner and Turolt<sup>7</sup> recorded the inhibitory effects of atropine and adrenalin on the strips of human muscle. Kuroda<sup>8</sup> recorded the behavior of the longitudinal muscle strips from the fundus of the dog's stomach. One of the most recent and complete studies on the movement, as well as the reaction of drugs, on strips of the gastric musculature of the cat and dog, is that of Brown and M'Swiney.<sup>9</sup> Their investigation was carried out on the excised strips of the cat and dog, in order to obtain further information as to the mechanism of rhythmic contractions and tonus in the different regions, and to ascertain the reaction of the various parts to autonomic drugs.

It is scarcely necessary to go into further detail regarding the work of these various observers, except to point out that their

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method of approach was more or less similar in many instances, and to call attention to the fact recorded by practically all of phase stomach is to be observed in cats. In the rabbit there occurs a rather marked thickening of the distal half of the pars

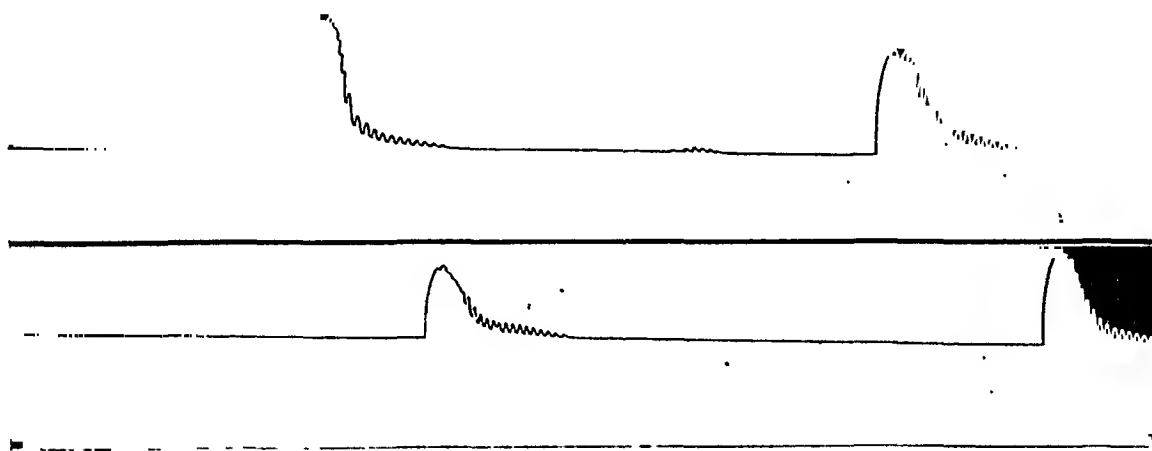


FIG. 1. Powerful rhythmic contractions from strip obtained from antrum and greater curvature. These are obtained apparently only from this region of rabbit's stomach.

them that there was an inherent rhythmicity and tonus which, as Alvarez has pointed out, was more or less characteristic of the portion of the stomach which was studied.

Our investigation had for its purpose the confirmation of these findings, and an attempt was made to show in what

pylorica, which would lead one, according to these authors, to suspect the existence of the separate non-peristaltic motor mechanism in this region. Additional support is given to this argument by the fact that the food in the stomach of this animal is always of a semi-solid consistency, and so there would be the need of a specially



FIG. 2. Extract of entire pyloric end of stomach has no effect on antral contractions as this curve illustrates.

way altering the reaction of the Locke's solution, which was used in these experiments, would alter the response. For our purpose we selected rabbits, which are admirably suited to this work. As M'Crea, M'Swiney, Morison and Stopford point out, the so-called two-phase stomach, in which peristalsis of the body, and systole and diastole of the antrum presumably occur, is characteristic of the rabbit, dog and man; while the so-called one-

adapted ejector mechanism. The observations of Alvarez are too well-known to need repetition. We were, therefore, interested not only in demonstrating the responses of the excised parts of the rabbit's stomach, but inasmuch as they lent themselves so readily to movements which are easily demonstrated, we carried on observations on the action of the acids and alkalies on the excised muscles, which are recorded in the following paper.

## TECHNIQUE

The animals used for these experiments were exclusively young rabbits. These

Locke's solution at the same temperature of  $4^{\circ}\text{C}$ .

The stomach was allowed to remain

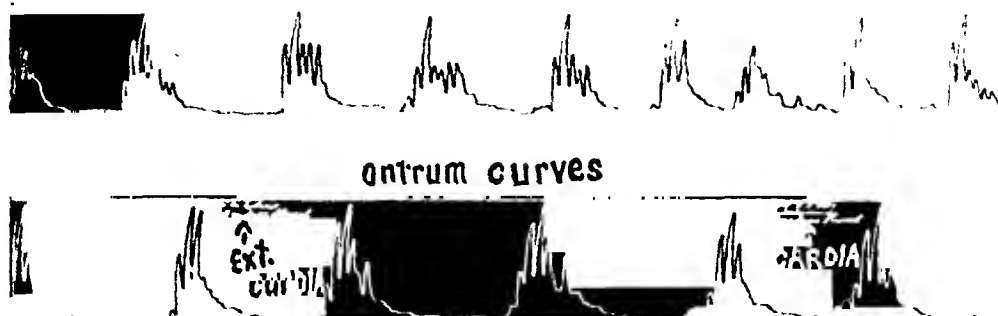


FIG. 3. Typical contraction waves from antral region and greater curvature. Notice that addition of emulsion of extract of entire cardiac portion including mucosa is without effect on contractions.

rabbits were killed by a sharp blow on the head, and the abdomen opened. The stomach was then exposed and removed intact. In practically every instance the stomachs were full, as no attempt was made to starve the animals. The stomach

in this solution for twenty minutes to half an hour, after which it was stretched out on a piece of cork under Locke's solution. The mucosa was then very carefully dissected away, leaving the muscularis and serosa which were then cut into

### PYLORUS-GREATER CURVATURE -acid response



FIG. 4. Effect of small amount of dilute hydrochloric acid on typical antral response with complete suppression of contraction waves. This amount is sufficient to carry pH to or just beyond neutrality according to observations of resulting mixture determined with calomel electrode.

was then transferred to Locke's solution at a uniform temperature of  $4^{\circ}\text{C}$ . An incision was then made along the greater curvature from the esophagus to the pylorus, and the material from the stomach completely evacuated. The stomach was then cleaned, and the organ placed in

parallel strips approximately 3 to 5 mm. in width, and 2 to 3 cm. in length. In several of the experiments the strips remained with the mucosa intact, but for our routine work the mucosa was dissected away. The strips were then kept in Locke's solution in a refrigerator,

the mean temperature being approximately  $4^{\circ}$ . In some instances the strips were employed immediately, and in others they

the strip was immersed in the solution was by means of a movable lever and side-arm, so that every change in the muscle strip was automatically recorded on a moving kymographic drum. The levers were extremely sensitive and specially adapted to this work. The apparatus was a type recommended by Dr. J. Earle Thomas as most effective for this purpose.

Time was recorded by a Jacquette mechanism, and the injection of substances was marked by an electrical indicator.

It is interesting to remark at this point that the tracing recorded from strips from different regions of the stomach was so characteristic that the observer was able, after a relatively short experience, to determine the region of the stomach involved. In other words, the contractions of any one strip were usually characteristic. Strips from the lesser curvature showed a distinctly smaller amplitude and greater frequency. In many instances the movements of strips from the cardia were very minute, and in some cases almost unrecognizable.

FIG. 5. Typical rapid rhythm of cardiac end and greater curvature strip. Acid inhibits response.

were used on the following day or even as long as forty-eight hours after removal.

The apparatus consisted of an outer container, holding perhaps 3 qt. of warm water, kept at a constant temperature of  $37.3^{\circ}\text{C}$ . by means of an electric thermostat. This container acted as a

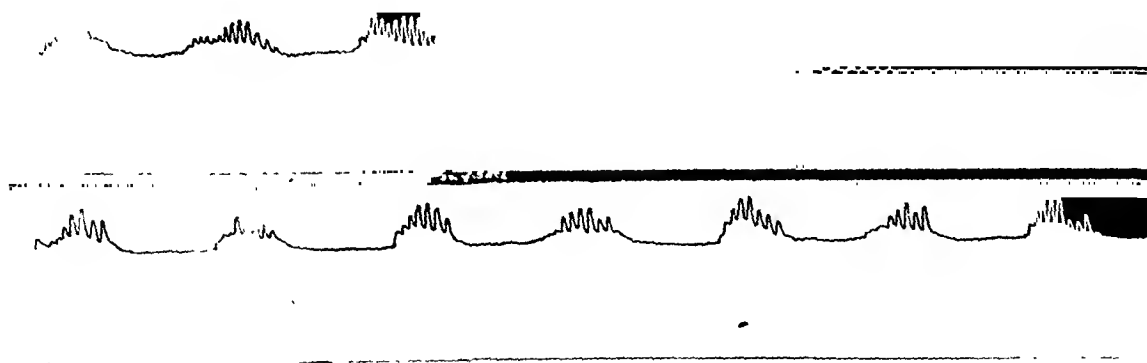


FIG. 6. Typical effect of addition of small amount of dilute hydrochloric acid (3 c.c. of 0.5 per cent HCl to 250 c.c. of Locke's solution) on surviving muscle strip taken from greater curvature antral end of rabbit's stomach.

water bath to maintain a constant temperature of the Locke's solution which was contained in an inner vessel holding approximately 250 c.c. Through the inner vessel containing the Locke's solution was an arrangement by which oxygen could be maintained at a given rate, so that the Locke's solution was aerated constantly. The arrangement by which

Muscle strips from approximately 90 animals were used, and throughout this series of experiments one can almost predict from the record of the tracing the part of the stomach wall which was being investigated.

In the great majority of cases our attention was directed to the phenomenon at the pyloric end of the stomach. In

about one-third of these cases records were made from the cardiac end of the stomach. Strips from the greater curvature

from balloons placed in the normal human antrum. The rhythmicity and the power of the contraction in that portion of the

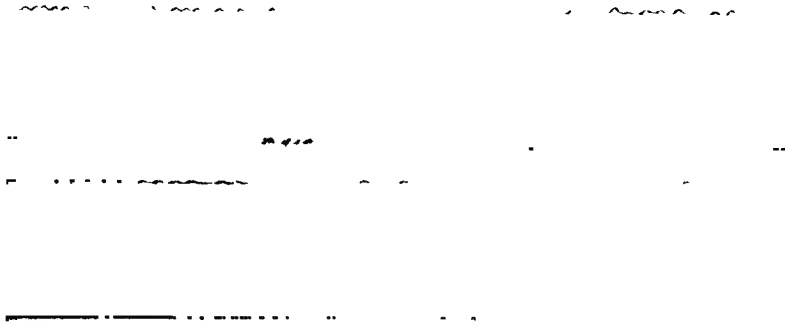


FIG. 7. Pyloric end, midway between greater and lesser curvature. Response resembles cardiac strips and 0.5 per cent HCl has only mild effect.

near the antrum and pylorus gave the most characteristic tracings. These were characterized by regular recurring groups of waves with a wide amplitude. In many instances the muscle strips would shorten to half their original length. Curves of

antrum adjacent to the pylorus and at the greater curvature, are out of all proportion to the response obtained in every other part of the stomach wall. Even in the lesser curvature and the antral portion no such contractions were recorded.

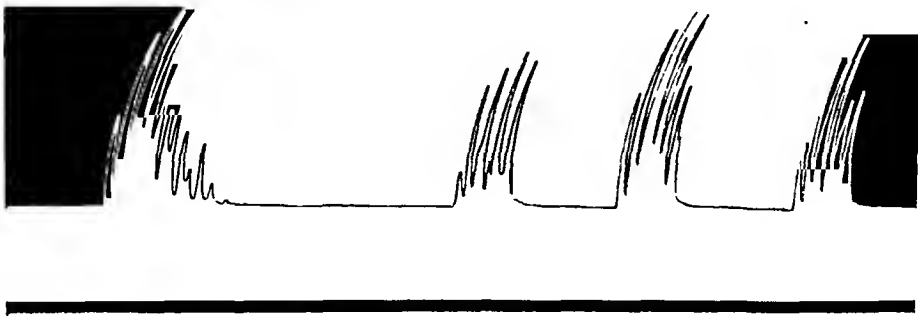


FIG. 8. Powerful rhythmic antral contractions seen most characteristically in antrum and greater curvature of rabbits stomach. These in no way resemble response obtained under identical conditions in lesser curvature, cardia and fundus and suggest a specialized musculature which we believe is concerned in major part of mechanical work of stomach.

this description are to be noted in the appended illustrations, and when the technique was satisfactory it was possible to get a graphic tracing which, in many respects, resembled the tracing obtained

In records of the lesser curvature, while there are considerable differences in tone and rhythm, the contractions were frequently regular, but never of the same amplitude, and this is true of the entire

fundus as well. In fact, we do not hesitate to make the statement that the important work in the rabbit's stomach is in all prob-

that the tracing obtained from the cardia and the antrum are different in type, form and amplitude, as one would expect

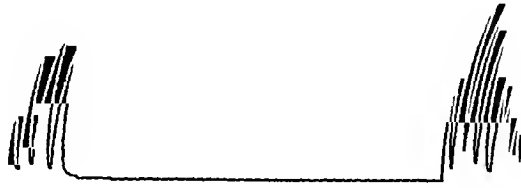


FIG. 9. Contractions from pyloric end and greater curvature. Notice amplitude of these contractions. These results are in accord with probability that greatest amount of work is performed specifically by this portion of stomach wall.

ability carried out by that part of the stomach wall involving the greater curvature near the antral portion.

Alvarez maintains that the excised strips of muscle from the cardiac end, and particularly that one on the lesser curvature next to the cardia, show the strongest tendency to rhythmic contraction. If by this he speaks of the frequency of contraction, then we are inclined to agree with his statement; but if rhythmic contraction implies a powerful recurring group of movements, then in our judgment the antrum near the pylorus undoubtedly fulfills this idea.

There are undoubtedly marked differences in irritability, latent period and contraction waves. As Alvarez maintains, to use his own words: "Speaking roughly, the rate of contraction varies inversely as the distance from the cardia." One gets the impression from this statement that the contraction rate at the pylorus, therefore, is very much less than that at the cardia: this is largely true; but as one studies these various responses, the fundamental impression is that there is no comparison between the pyloric and antral contractions on the one hand, and the characteristic response seen in the cardia. The observations of Sick, Tedesco, Smith, M'Swney and others, certainly suggest

regarding their obvious differences in function. In all the muscle strips that we studied, there was never encountered at or near the cardia a record which resembled the characteristic tracing of the antrum, and the reverse is likewise true. It is difficult or impossible to establish any relationship between the two, and if this



FIG. 10. Recurrence of gastric muscle contraction which had been inhibited by addition of dilute HCl and in this response brought back by addition of sodium bicarbonate solution.

relationship exists it is not apparent from our studies.

In the balloon work done on human beings by Thomas, Eads and Rehfuess, antral contractions were powerful, regular, and frequently preceded by a slight increase in tonus. There is a striking similarity between many of our responses, and those which were seen by the intra-gastric balloon such as one of us recorded some time ago.



In practically all instances the strips which we used in our work were taken longitudinally. We tried strips which were with the poor amplitude of contractions in the strips from that region. Nothing in the gross appearance of the strip would



FIG. 11. Surviving muscle strip from cardiac end of stomach. Notice typical contractions totally unlike those of cardia and notice that repeated additions of 0.5 per cent HCl fails to arrest cardiac contractions.

circular, but the records obtained were unsatisfactory. Therefore, for practical purposes, in all instances this work was recorded on longitudinal strips. There are, of course, many differences observed in suggest this fact. Alvarez also notes as he has commented elsewhere on the fact that as tone rises the amplitude of contraction falls, until rhythmic activity may cease entirely. This may be true on some

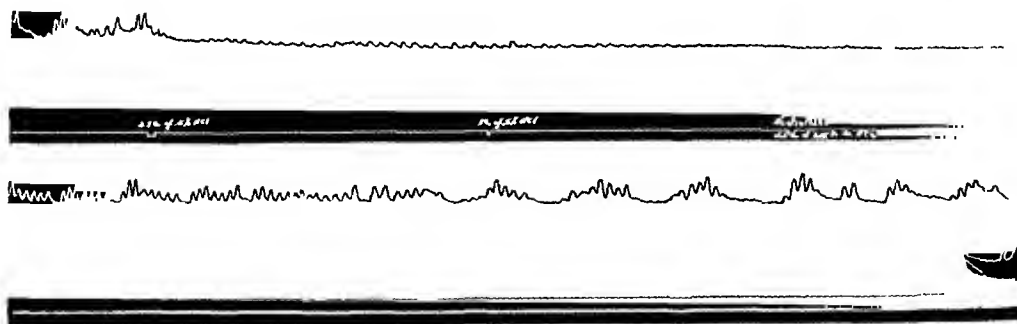


FIG. 12. Addition of 3.5 c.c. of 0.5 per cent HCl causes alteration in muscle strip response which is inhibited altogether by addition of 1 c.c. more of dilute HCl.

the tonus of the strips, and at times a distinct increase in tonus was recorded, when there were no contractions. Tonus naturally can only be recorded in this sort of work by the position of the lever above the baseline, which records the contraction of the muscle strip. Alvarez suggests that high tonus of the lesser curvature might have something to do

occasions, but it is certainly not invariably true, as will be seen from certain contractions with bicarbonate of soda, for instance.

Just what is the influence of the histological structure in these different parts of the stomach, we are not prepared to state. We are convinced of the fact, however, that the reaction of the excised muscle strip in the cardia and in the pyloric antrum

in the rabbit is very different. We are further of the opinion that this difference is a characteristic one inherent in the part

offering the typical tracings illustrated in this article.

In view of the fact that it is possible

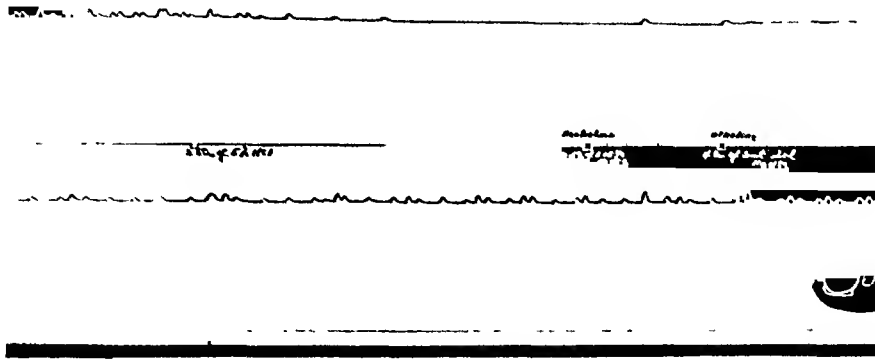


FIG. 13. Strip from lesser curvature all the way from the esophagus to the pyloric sphincter. Note similarity in response to type of contraction noted at cardia. Acid inhibits and alkali restores contractions as ensuing curves demonstrate.

of the stomach which was being observed. We furthermore believe that the greater curvature portion of the antrum is that part concerned in the most regular and powerful rhythmic contraction, and finally we are unable to demonstrate definitely any relationship between antral and cardiac contractions. They are different both

to obtain under ideal experimental conditions tracings which can be reproduced and which are highly characteristic, it was of great interest to note the effect of certain substances, notably those connected with gastric function, or what Babkin would call natural chemical stimuli on these muscle contractions. The most

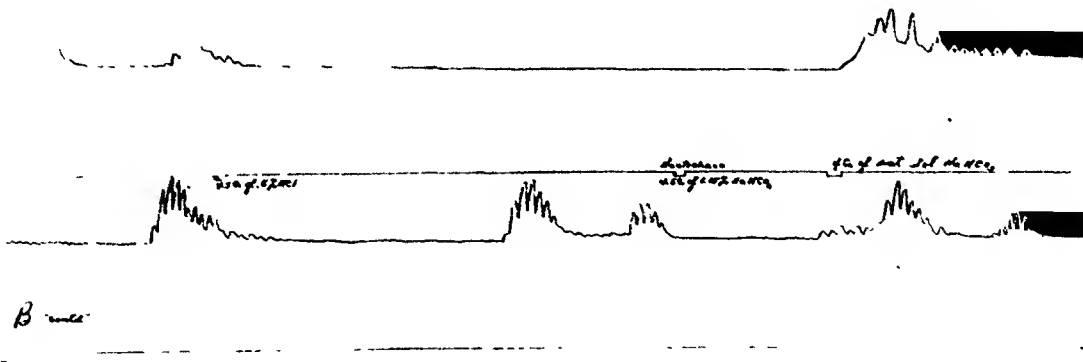


FIG. 14. Muscle strip from antral region and greater curvature. Notice disappearance of contractions on addition of 4.5 c.c. of 0.5 per cent HCl and their reappearance after addition of sodium bicarbonate.

in form and type, and a study of our responses would make us hesitate to say that even roughly the rate of contraction varies inversely as distance from the cardia. Our observations would suggest that the contractions are very different in both type, form and tone in the two parts of the stomach wall. For that purpose we are

interesting substance is hydrochloric acid. The action of dilute hydrochloric acid and alkalis such as sodium bicarbonate has been repeatedly discussed in the literature. The influence of natural chemical stimuli on the movements of the frog's stomach was studied by Babkin.<sup>10</sup> In this contribution the author points out that solutions

of hydrochloric acid introduced into the stomach, according to Glassner<sup>11</sup> are non-effective; according to Lussana<sup>12</sup> they increase and afterwards arrest its spontaneous contractions; according to Patterson<sup>13</sup> they arrest without previously increasing the hunger contractions; and finally, Hoff<sup>14</sup> noted an increase in contractions. Babkin asks the question as to whether the acting chemical agent being the same, the various motor responses are not due to unequal stimulation of the neuromuscular apparatus of the stomach itself. He studied the stomach of the frog which was excised, and in which solutions were introduced under the definite pressure. The volumetric registering of stomach contractions was made on a kymograph, and at the same time the author made tracings of the separate contractions. He found that the most active part of the stomach of the frog was the pyloric part. Hydrochloric acid exerted a varying action, depending upon its concentration. In weak solutions it increases the contractions and diminishes the frequency at 0.5 HCL. In some concentrated solutions (0.05 per cent to 0.2 per cent) it arrests them. He then found that the effect of sodium bicarbonate (0.03 per cent to 0.05 per cent) is to arrest the tone and increase the intensity and frequency of the contractions of the frog's stomach.

In other words, these experiments were performed by injecting the material in the stomach. We are not familiar with the effect of the alteration of the hydrogen iron concentration of Locke's solution on the excised muscle strips.

#### THE EFFECT OF HYDROCHLORIC ACID

In this experiment we arranged the apparatus in order that we could obtain the typical responses. Ordinarily a controlled tracing was made after the contractions had reached a uniform type for at least thirty or forty minutes. At this point from 1 to 5 c.c. of a 0.05 per cent solution of hydrochloric acid was injected into

the Locke's solution. It is needless to point out that the amount of hydrochloric acid in the solution, when diluted, represented an infinitesimally small amount of acid. In other words, if 5 c.c. of 0.5 hydrochloric acid were added to 250 c.c. of Locke's solution, the resulting mixture would represent 0.01 per cent hydrochloric acid. At this figure we were able to demonstrate unmistakable changes in the appearance of the waves. Almost uniformly it was possible, by the addition of hydrochloric acid in the quantities mentioned before, to cause either marked inhibition or a total arrest of the contractions. In some instances, the interval between the contractions was prolonged. In others, the contraction gradually faded away, and in a number of these responses there was a complete disappearance of the contraction.

It was therefore evident that dilute hydrochloric acid in dilutions far smaller than those commonly encountered, but nevertheless showing a change in the hydrogen iron concentrate caused a diminution or cessation of the contractions.

In view of this practically constant finding, it was of interest to note the effect of other substances. The first substance which was used was sodium citrate. The addition of small amounts of sodium citrate, 1 to 5 c.c. or more, a saturated solution, not only caused a reappearance of the contractions, but in some of the preparations where hydrochloric acid was not used, it caused an increase in tonus and sometimes in the frequency of contractions. This observation was strikingly constant in the series of cases where it was used.

Sodium bicarbonate used in the same way, namely, a saturated solution of quantities of 5 c.c. and over, likewise had a similar effect. In some instances there was a very much greater increase in tonus, and if the tracing was recorded over considerable intervals, a complete reappearance of contractions which were, if anything, more rhythmic and more pronounced than before hydrochloric acid had been used. It is to be noted that not only is

there an increase in tonus, but that in the majority of instances the inhibitory effect of hydrochloric acid is overcome and followed by pronounced contraction.

It was interesting in this work to observe whether or not extracts from different parts of the stomach might not have the same effect. For this purpose we prepared macerations of the fundal and pyloric portions of the stomach in normal salt solution. We were unable to demonstrate any definite effect from either of these tissue extracts, as the following short table will reveal.

We also used in several experiments liver extract 343 of Lillic's, and also the 4-C liver extract which was prepared in our laboratories. On one occasion we were able to get a response from liver extract. This finding, however, was an inconstant one, and we feel that our studies do not justify the conclusion that liver extract stimulates the gastric musculature. Studies which will be reported elsewhere by us, however, do prove that the upper digestive tract is certainly influenced by this preparation.

#### CONCLUSIONS

1. The reaction of surviving muscle strips from different portions of the stomach of a rabbit is highly characteristic.
2. Longitudinal preparations from the cardia gave a response which is essentially different from that obtained at the pyloric antrum.
3. The most powerful rhythmic contractions were obtained from that part of the antrum involving the greater curvature.
4. The most frequent waves of small amplitude are obtained at or near the cardia.
5. Hydrochloric acid in dilutions mentioned in the text, inhibits or arrests the pyloric antral contractions.
6. Sodium citrate in a number of instances causes a reappearance of the contractions following their disappearance due to hydrochloric acid.

7. Bicarbonate of soda has the same quality.

8. In the majority of our studies there was a perceptible increase of tonus on the addition of bicarbonate of soda.

9. Normal salt solution extracts of the fundus and antrum failed to show any appreciable effect on muscle strip preparations.

10. It is possible that some liver extracts may stimulate these contractions.

After studying these charts and the behavior of the muscle strips under these experimental conditions, one hesitates to assume changes in hydrogen ion concentration as important factors in peristalsis. Certainly there can be no question that minute amounts of acid and alkali can markedly alter the sequence of events. A mechanism involving regular recurrent changes in hydrogen ion concentration might be suggested as a hypothesis for peristalsis.

In conclusion, the results mentioned here were obtained from a series of studies on isolated muscle strips from different parts of the stomachs of about 90 rabbits.

We are indebted to those who contributed to the Medical Research Foundation at Frankford for financial support in these experiments, namely, Mrs. Cyrus H. K. Curtis, Mr. Alvan Dinkey, Mrs. Henderson, Mr. H. M. Pierce, and Mrs. Buckner.

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## DISCUSSION

DR. BASTEDO: As an old pharmacologist, I just want to emphasize something that Dr. Rehfuss mentioned, and that is the fact that the acids and alkalies will not be found affecting this muscle strip in the living stomach, but only in the mucous membrane. You must not get that impression, because the muscular layers are not affected chemically by what is in the stomach, but rather by what is brought to them by the blood stream.

DR. REHFUSS (*closing*): I am very much interested in the reference to the motion of the pyloric valve. These are the things that impressed us in our work. Dr. Alvarez' idea is that this is more or less continuous, but I think that the phenomenon that I have presented here today is an altogether different phase of digestion, an altogether different thing. This beating of the pylorus in rabbits is a beat which is powerful, regular, recurrent, and is, so far as I can find, the only part capable of doing work. Therefore, I was interested in Dr. Coles' description of his idea regarding the fan shaped muscle he describes. I would like to show him some of the records we have. There is

another thing which I would like to point out, and that is, that if there is anything which affects the muscular tissue it is not in the stomach, but it is, rather, something perhaps chemical alterations in the blood circulating through that particular part of the stomach wall. There is one thought that occurs to me, and that is, that, with the large amount of acid which must be derived from the stomach may result in changes in the tonus of this region of the stomach, any change which occurs must occur during the gastric digestion and not the intestinal digestion. It is clear that there is some general mechanism which brings about a change in the pH, which probably is induced by the formation of a large amount of secretion. It seems almost impossible for us to believe that we can get a pint or a quart of stomach secretion, without some radical, chemical change. I believe that the distal end is motor in its function, and that the cardiac end is built for storage. I think that the chemistry relates to a hormone which is secreted by some mechanism which operates in the entire digestive tract, and is, perhaps, part of a far-flung mechanism which may reach further than the stomach.



# CHRONIC HYPERPLASTIC TUBERCULOSIS OF THE ILEUM\*

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IN the *Annals of Surgery* for May 1930 Edward Dowdle<sup>1</sup> reports a case of chronic hyperplastic tuberculosis, or tuberculoma of the descending colon, as he calls it. In his discussion of the various types of tuberculosis of the intestines, he states that chronic hyperplastic tuberculosis of the ileum alone is almost never seen, only 8 cases having been reported in the literature.

Dowdle states that this variety of tuberculosis is considered a primary lesion in a high percentage of cases both because of the inability to demonstrate tuberculous infection elsewhere and because of the cure by extirpation of the local lesion. Occasionally however, tuberculosis elsewhere is demonstrable as a coexisting lesion. Boyd<sup>2</sup> in his *Surgical Pathology* states that in this condition there is formation of tuberculous granulation tissue, mainly in the submucosa, but also to some extent in the subperitoneal coat; that giant cells are abundant, but that miliary tubercles are not common and that caseation is usually absent. Ulceration may develop, but is not a marked feature of this condition. The mucosa may gradually encroach upon the lumen until extreme narrowing results, so that it may only be possible to pass a fine probe through the opening. The affected part of the bowel is thickened and stiff and may form a tumor-like mass, which bears strong resemblance to a carcinoma even after the abdomen is opened. The neighboring lymphatic glands are usually enlarged, thus still further adding to the mass which is felt through the abdominal wall. Rankin and Mayo<sup>3</sup> in *Surgery, Gynecology and Obstetrics* for June 1930 under the heading of Carcinoma of the Small Bowel state that localized tuberculosis of the ileum must be remembered as one condition difficult to distinguish from carcinoma except at operation. They

also mention a case of localized tuberculosis of the ileum 75 cm. from the ileocecal valve, thus bringing the total of cases in literature to 9. Babcock<sup>4</sup> in his "Textbook of Surgery" under Tuberculosis of the Intestine gives as one of his classifications: Hyperplastic form, large infiltrating ulcers or polypoid granulations upon the mucous membrane, partially annular and tending to stenosis and stricture . . . bowel above the stricture is hypertrophied or dilated or both thick and dilated. The ulcers show dense fibrous hyperplasia with limited caseation and necrosis, and with stenosis and obstruction and enlargement of the regional lymph-nodes. All of the writers mentioned previously state that this type is found between the ages of twenty and forty, rarely in children and the elderly.

We wish to add a case of localized hyperplastic tuberculosis of the ileum to those already mentioned in literature. The clinical picture corresponds almost exactly with that mentioned by Babcock.

A patient between twenty and forty years of age gives the symptoms of chronic intestinal stenosis . . . there is cachexia, wasting, anorexia, colic, rumbling, occasional vomiting, visible peristalsis, rarely blood in the stools, a firm, hard, nodular, usually cylindric tumor is felt most frequently in the ileocecal region. This is not tender or painful; does not move with respiration, but may be moved by the fingers; there is little or no fever unless an abscess is present.

## CASE REPORT

Mr. J. H., aged twenty-two years, white, single, laborer.

*Chief Complaint.* Gas, distention and pain one hour after meals of one year's duration.

*Family History.* Father living and well. Mother died of pneumonia one year ago, aged fifty-four years. Four brothers and three sisters living and well. One brother died in infancy. One brother died of diphtheria at the age of

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three. No history of tuberculosis in the family. Denied any known contacts with anyone having tuberculosis. No history of cancer or diabetes in family.

*Past History.* Measles, mumps, whooping cough during childhood. No other illnesses. No headache. Eyes normal. No ear trouble. Occasional sore throat and no tonsillitis. Tonsils not removed. Teeth in good condition. Cardio-respiratory: No cough or night sweats. No loss of weight previous to present illness. Gastrointestinal: No stomach trouble before present illness; not constipated. The patient had an appendectomy at the Binghamton City Hospital just prior to the present illness. Genitourinary: Nocturia none. Denied venereal diseases. Neuromuscular: Has always been thin, but in good health. Habits: Does not drink or smoke.

On February 17, 1929, the patient was admitted to the Binghamton City Hospital with chief complaint of pain below the navel, dull and intermittent in character of ten days' duration. He stated that he had had a cold during this time. The pain became more severe on the day of admission and was associated with some vomiting. He had no chills. His bowels moved normally. There were no urinary complaints. He denied any previous similar attacks. The past history otherwise corresponded exactly with the history given here. The report of the physical examination states that the abdomen was not distended. There was no rigidity, no tenderness, and no rebound pain. Rectal examination was negative. Temperature 98.6°F.; pulse 80; respiration 20. Blood count normal. The opinion was subacute appendicitis. In the description of the operation, it is noted that the appendix was somewhat larger than normal and the blood vessels congested. A microscopic examination was not done. Two Wassermann tests were made, which were negative. Apparently the amount of pain of which this patient complained was more than that expected from the pathology found in the appendix and the Wassermann test was repeated to rule out a possible central nervous system lues. His convalescence was uneventful, and he was discharged on February 27, 1929 completely relieved of symptoms.

*Present Illness.* In June 1929, about four months after his appendectomy, the patient began suffering from gas and distention begin-

ning about one hour after meals. He also complained of marked constipation. He denied any night sweats, coughing or pain in the chest. He lost weight rapidly however until he was put on a Sippy diet. On this regime, he soon gained his weight back and had complete relief from his symptoms. After a month however, he began gradually to have the same complaints with occasional periods of relief. He was then changed to an hydrochloric-acid and pepsin regime. This did not alter the picture in the slightest, the patient still having his occasional periods of freedom from pain, but his general condition remaining about the same. On February 28, 1930 a gastrointestinal series was made and found negative for any pathology. On April 1, 1930, he was readmitted to the Binghamton City Hospital. At this time his temperature was 98.4°F.; pulse 84; respirations 24. He stated that the gas and sour eructations were worse now and occurred after every meal. He had lost about 17 lb. in the past six months.

*Physical Examination.* The patient was a markedly emaciated young white man apparently in no great pain. Examination of the head, eyes, ears, throat, and teeth was negative. The heart and lungs were negative to auscultation and percussion. The abdomen was markedly distended and gave the impression of containing fluid, although none could be made out. Peristalsis was marked on auscultation, but was not visible. No special points of tenderness or muscle spasm were elicited. There was a fixed mass about the size of a grapefruit in the right ilioinguinal region just median to the appendectomy scar. This was not tender and did not move with respiration. Owing to the distention, it could not be outlined accurately. This did not move with the position of the patient and could not be moved manually.

Enemas were given and returned with fair results.

*X-ray Reports,* Dr. U. S. Kann, April 1, 1930, gastrointestinal tract: "Stomach shows a pronounced pyloric defect. No pyloric cap. Transverse and descending colon show up well. There seems to be a mass of adhesions of the colon in the descending loop of the colon and small intestines. There is a marked defect after the hour plate, giving the appearance of a tumor mass in the lower right quadrant, pushing the descending colon. There is a calcified area in the right lower quadrant



opposite the fourth lumbar vertebra. Question of tumor in the right lower quadrant. Origin unknown."

X-ray of chest, April 4, 1930: "Large hilum on the left side well infiltrated. The general aspect of the right and left lungs is clear. The heart is globular shaped and well in the middle line. Diagnosis: Large infiltration of the hilum on the left side. Negative for tuberculosis." The gastrointestinal series apparently aggravated the partial obstruction which was present. The patient became nauseated and vomited. He also complained of continuous pain. The abdomen became more distended and violent peristalsis could be seen. The distention of the abdomen was so marked and the condition of the patient such that a palliative colostomy was contemplated. It was decided, however, to first attempt to build up his general condition by the use of repeated intravenous injections of glucose and saline. Turpentine stupes were applied to the abdomen. All fluid and medications by mouth were discontinued except bowel sedatives. After twenty-four hours, the peristalsis seemed to have abated to some extent, and the patient was given fluids by mouth. This was increased to soft diet two days later. His general condition improved coincidentally with the bowel improvement. The distention, however, persisted. His temperature during this time ranged from 98° to 100°F.

*Blood Count*, April 15, 1930, 75 per cent hemoglobin, 4,420,000 erythrocytes. The white count was 7400 with 67 per cent polymorphonuclear neutrophils, 32 per cent lymphocytes and 1 per cent large mononuclears. There were no abnormal red cells. The color index was 0.8. Urinalysis was normal.

The patient was operated on April 15, 1930. The preoperative diagnosis was partial obstruction due to tuberculous peritonitis. Gas-oxygen-ether was used.

*Procedure.* High right rectus incision. The rectus muscle was split and the peritoneum was incised. On opening the abdomen a small amount of clear serous fluid was present. The bowels were moderately distended. The serous covering was shiny and the blood vessels engorged. Examination of the stomach and gall bladder was negative. No adhesions from the previous appendectomy were noted. In the right lower quadrant just below and medial to the cecum was a large mass about the size

of a grapefruit with the bowel above it markedly dilated, thickened and edematous for about 2 ft., so that at first glance it appeared to be large bowel. Upon examination, this mass was found to be ileum and underlying enlarged mesenteric lymph glands about 18 in. proximal to the ileocecal valve. The lymph glands were fused and about the size of a small orange. The section between the ileocecal valve and this mass was normal in appearance although somewhat injected. The cecum and colon were normal in appearance and exploration of the rest of the abdomen was negative for further pathology. About 1½ ft. of small bowel was resected beginning about 3 in. distal to the tumor and approximately 9 in. above it. Because the glandular mass was so adherent to the underlying blood vessels, it was left intact. The ends of the bowel were then united by side to side anastomosis, this being considered advisable lest the line of suture become adherent to the glands and stricture with obstruction of the bowel follow. Enterostomy was performed above the anastomosis and the enterostomy tube let out through a stab wound in the side. Through and through dermal tension sutures were inserted and the wound closed in layers with chromic catgut. No drains were used. The patient's condition while on the table was only fair, his pulse ranging from 130 to 140. An intravenous injection of glucose and saline was given in the operating room and was repeated when the patient was sent to the ward.

The patient's convalescence was uneventful. At the end of two weeks, at the suggestion of a medical consultant, alpine light was applied to the abdomen. This caused an immediate rise in temperature to 102°F. and occurred whenever this was applied. After three attempts, the light was discontinued. The patient was discharged from the hospital on May 23, 1930, seven weeks after admission. The wound was entirely healed. His general physical condition was very good, his weight being 127 lb., 12 lb. more than on admission. He was on a regular diet, and had no gastrointestinal symptoms whatsoever.

*Pathological Report*, Dr. Edward L. Saylor, gross pathology: "The specimen is a part of the small intestine. It measures 40 cm. in length and from 2 to 11 cm. in diameter, the different measurements representing cicatricial and dilated portions respectively. The serosa

appears moderately congested and some normal appearing mesenteric fat is attached along the outer border. The thickness of the intestinal wall varies from 5 mm. to nearly 2 cm. The thickened area represents a scar evidently on the side of a previous ulcer. The mucosa in this region has a grayish granular appearance and there are denuded areas which exhibit the underlying scar tissue. Immediately above the scarred area the intestine is dilated and the mucosa mostly destroyed by a diffuse ulcerative process. There are some ulcers which are well defined and show a dirty gray granular base. These isolated ulcers average 3 by 2 cm. and their long diameter is parallel with the lumen of the intestine. The mucosa between the ulcers is also more or less disintegrated, evidently from the same process and small hyperplastic appearing tissue peripheral to the inflammatory area."

*Microscopical Examination.* "Numerous sections taken through the wall of the intestine both from the thickened portion and also from the ulcerated areas show a high grade subacute inflammatory process. In the hypertrophic areas there is a marked increase in fibrous tissue and the mucosa is entirely destroyed by granulation tissue. In this latter region there are newly formed capillaries and marked round cell infiltration. There are other sections that show some of the mucosa and in the ulcerated areas there is marked necrosis of the mucosa and this is replaced by a thick fibrino-purulent exudate. In one section, however, there is a well defined anatomical tubercle with epithelioid cells and typical Langhans' giant cells in the center. In another section there is also a giant cell reaction but no epithelioid cells are seen here. Final diagnosis: Ulcerative tuberculosis of small intestine with partial obstruction due to cicatricial contraction."

The patient reported at the office on June 25, 1930. At this time his weight was 134 lb. He stated that he had had no stomach complaints whatsoever and wanted to go to work. September 1, 1930, the patient's weight was 145 lb. He had been working every day and was apparently cured. Physical examination was negative for any signs of recurrence or of abdominal pathology.

In conclusion: this case brings the total of reported cases of localized hyperplastic tuberculosis of the ileum to 10. Attempt was made to obtain reports of the previous 8 known cases, but as only 4 of these were secured, it was deemed best not to summarize them. These are noted in the bibliography.<sup>5</sup> The characteristic history brought out by these cases and so very ably summarized by Babcock was demonstrated in our patient. To date there have been no signs or symptoms of recurrence or of tuberculosis elsewhere in the body. Our experience in this case agrees with Dowdle's conclusion that this condition is *localized* and that removal of the lesion will cure the patient.

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# PSYCHOGENIC FACTORS IN CARDIOSPASM\*

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*Introduction:* The cause of cardiospasm is indeed obscure. To illustrate the divergence of opinions some of the theories are presented:

1. It is a congenital mega-esophagus (Bard).<sup>1</sup>

2. A pre-gastric pouch or vormagen (Zusch).

3. The result of valve formation due to the entrance of the esophagus at an acute angle into the stomach (Strauss).

4. The result of a constricting action of the diaphragm (Sauerbruch).

5. Obstruction in the "liver tunnel" (Mosher).<sup>2</sup>

6. Spasm in the upper sulcus gastricus below the cardia (Fleiner).

7. A primary atony of the musculature of the esophagus (Rosenheim).

8. Spasm of the cardia as part of a general spasmophilia (Wilms).

9. Esophagitis due to various causes with secondary cardiospasm (V. Mikulicz).

10. Functional or organic disease of the vagus nerves (Krauss).

11. Disease of Auerbach's plexus at the cardia (Hurst).

12. A failure of the active opening of the cardia (Cardioparalysis or achalasia, Zaager, Hurst).

13. A reflex disturbance of the vegetative nervous system control of the cardia (Heyrowsky, Soper).<sup>3</sup>

14. Injury of nerves or nerve plexuses by physical trauma (Krauss).

15. The result of psychic insults (Brairowskaja, Winkelstein).

16. Ductless gland disturbance, particularly ovarian (Struempell).

None of these theories seems sufficient to explain all or even the majority of the cases. It is probable that cardiospasm is, in most of the instances, a symptom rather than an independent disease. Physiologically the disease can best be explained by postulating a disturbance of the nervous regulation of the cardia. Obviously, such a disturbance may be brought about in many ways. It is the purpose of this paper to emphasize one way in which this syndrome may be produced.

In a series of consecutive cases, we have been impressed in the last few years by the prominence of psychic upsets at the beginning, and during the course of the disease. Because it seems possible that there is a causal connection between these mental disturbances and the cardiospasm, this group of cases is submitted for consideration.

Before giving you the details of the case histories, two points should be emphasized. (1) That all of these patients have had a complete examination in order to exclude the presence of disease elsewhere in the body, and (2) that they are not examples of slight or transient spasm of the cardia or esophagus, but as you will see in the radiographs, they are true instances of chronic cardiospasm with marked dilatation of the esophagus.

CASE 1. M. K., male, aged twenty-three. He has had dysphagia and regurgitation for eleven years. Radiography showed a typical cardiospasm with marked dilatation of the esophagus. When twelve years old while attending school in Russia, he was caught eating a sandwich, which was contrary to the school rules. The teacher struck him over the head, he choked on the food, and was rushed to a hospital. There he overheard the physicians discuss the possibility that an operation might

<sup>1</sup> Thieding, F. *Beitrag z. klin. Chir.*, 121: 237, 1921. (Here will be found most of the references cited.)

<sup>2</sup> Jackson, C. *Nelson's Looseleaf System of Medicine*. Vol. 5.

<sup>3</sup> Soper, H. W., and Cassidy, L. D. *Tr. Am. Gastro-Enterol. As.*, p. 86, 1928.

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be necessary. That night, in a terrified state, he jumped out of a window in a nightgown, and ran home bare-footed in the snow, a distance of some miles. Since then, he has had symptoms of cardiospasm. A few years later he came to the United States. He became the chief support of his family, and was worried by financial difficulties. For several years hydrostatic dilatation with the Russel-Plummer apparatus gave him only slight relief. Then he disappeared from observation for two years. On his return, he informed us of a fortunate marriage with a wealthy bride, with resultant relief both from financial troubles and his symptoms. Occasionally, there is a mild recurrence under some emotional stress or strain.

CASE II. M. S., female, aged forty-five. She has had dysphagia, regurgitation, and epigastric discomfort for twenty years. Radiography again revealed typical cardiospasm with marked dilatation of the esophagus. Her symptoms began immediately after swallowing the cap of a gold tooth. She was told by a physician that she had cardiospasm, and would suffer from the disease until her death. She thought it was cancer, and has secretly hugged that idea for twenty years. Further mental stress was caused by her marriage at the time of the onset of her symptoms to an old, sickly, and impotent man. She has been helped somewhat by repeated dilatations with the hydrostatic dilator. Psychic approach failed because she was un-cooperative.

CASE III. W. A., colored male, aged thirty-four. He complained of dysphagia, regurgitation, and loss of weight for seven years. Radiography revealed cardiospasm with an enormous esophagus. His symptoms commenced immediately after marriage. The patient, a mild, meek, little man, found himself married to a wife who was a terrible nag, constantly scolding him for not earning a living. Furthermore, she was an alcoholic, and their life consisted in orgies of drinking, dancing, and sexual excesses. All of this, he informed us, worried him greatly, and aggravated his symptoms. The Plummer dilator helped him considerably. Recently, his economic situation is better, and his symptoms have lessened. A quarrel with his wife causes a recurrence of his symptoms, and is followed by a visit to the gastrointestinal clinic for a dilatation.

CASE IV. S. F., a male, aged twenty. Seven years ago, while sitting in the window of a tenement house, the patient saw a woman run over by an automobile. The candy he was eating stuck in his throat and he fainted. Since then he has had his dysphagia and regurgitation. Radiography showed a markedly dilated and redundant esophagus. Dilatations and vagolysis have not helped him. He is decidedly a psychopathic type—quiet, moody, and shuns society.

CASE V. A. M., boy aged eight. His symptoms commenced three years ago following the accidental swallowing of a large piece of iced candy which stuck in his throat. This child was observed on the Children's Ward where he was considered mentally abnormal. He refused to play with the other children, and seemed very quiet and depressed. His esophagus was moderately dilated. He left somewhat relieved after one dilatation.

CASE VI. S. R., male aged forty. Immediately following the incision of a peritonsillar abscess twelve years ago, this man developed the symptoms of cardiospasm. Careful questioning brought to light the fact that this man has lived for years in a terrified state. His son, perhaps a pervert, has belabored his father with mental and physical cruelty. The patient is a pitiful, trembling wretch in constant fear. Radiography shows a typical picture of cardiospasm with a moderate dilatation of the esophagus.

CASE VII. R. G., a girl aged seventeen. From the age of eleven to thirteen this girl masturbated excessively. When thirteen, she read a popular sex book which stated that onanism was criminal, and would lead to insanity. Through fear, she at once stopped the onanistic act, but since then, for four years, has had the symptoms of cardiospasm. Radiography shows cardiospasm with a moderate dilatation of the esophagus.

CASE VIII. L. L., a female aged forty. Four years ago, she was suddenly informed in the middle of the night that a dearly beloved sister had been burned to death. The next day, dysphagia and vomiting set in. This patient, also, is unhappily married. She suffers tremendous sexual disgust. After each sexual act, she has nausea and vomiting. A surgeon performed an extramucosal cardioplasty, and a vagus

nerve resection without relief of symptoms. Plummer dilatation was very successful in her case, a single dilatation being followed by a gain of 45 lb. in three weeks.

#### DISCUSSION

It is apparent that, in this group, psychic disturbances have played an important rôle. It will be necessary, therefore, to study cases of cardiospasm carefully for psychogenic origins.

Whether one is a Freudian, and considers these patients as conversion neuroses, or is of the school of Adler, which would maintain that the patients employ the disease as a weapon of defense and offense in their conflict with society, or, whether one agrees with the Pawlow school of conditioned reflexes, is immaterial. What is important, we feel, is the adoption of the conception that these patients, fundamentally neuropaths, have suffered psychic traumas, and that these abnormal mental stimuli have in some way affected the innervation of the cardia through the vegetative nervous system. Without discussing the vagus and the sympathetic, we may say that the result is a failure of the cardia to open normally before the advancing esophageal peristaltic wave, which constitutes cardiospasm. In the chronic, advanced cases, the esophagus dilates, hypertrophies, becomes inflamed, and the disease picture is complete.

In favor of the view that the mental states have a causal connection with the disease is the frequency of esophageal symptoms in psychic upsets. We are all familiar with the expressions, "there is a lump in my throat," "I can hardly swallow," "the food sticks." The following symptoms certainly occur prominently in mental disturbances: globus hystericus, substernal pressure, dysphagia, regurgitation, heartburn, belching, nausea and vomiting.

It is not intended to deny that cardiospasm may be produced in other ways, for example, by organic disease of the vagus nerves, or by reflex stimuli from diseases

elsewhere in the body as Dr. Soper emphasized in 1928.

Finally, let us point out the value of distinguishing this group. Of course, it helps to clarify somewhat this obscure disease. Then, it furnishes an excellent example of a functional disturbance leading to an organic disease, the physical link between the psychic disturbances and the cardiospasm being the vegetative nervous system. Also, it may prove helpful in therapy. Recently, we have encountered 2 cases of psychogenic cardiospasm with short histories and definite radiographic evidence of cardiospasm. The first patient's symptoms came on after a partial gastrectomy for duodenal ulcer. This patient confessed to cancer-phobia, and she was cured clinically and radiographically, by psychotherapy. The other patient was the sister of the Russian boy who was struck over the head by his teacher. This young girl developed symptoms of cardiospasm while her brother was being treated by dilatations. She was entirely cured by psychotherapy. It is possible that psychotherapy may cure in the early stages, and that in the chronic cases it may be helpful in addition to dilatation.

#### CONCLUSIONS

In conclusion, it seems permissible to state that (1) cardiospasm is a disturbance of the vegetative nervous system regulation of the cardia so that it fails to open properly and dilatation of the esophagus results; (2) this dysregulation or dysfunction may be brought about in many ways; (3) in the group of patients presented here, psychic factors seem to be the chief agents in producing the disease; (4) psychotherapy may prove helpful in the treatment of this type of cardiospasm.

#### DISCUSSION

DR. VERBRYCKE: I know that there are some observers who claim that no psychic factor plays a part in inducing cardiospasm, that it is a real organic disease. I think however that there are some cases which have started

from a mental shock or nerve strain. I recall an excellent example, a physician of the Mexican national railways. He was cured of a real honest-to-goodness cardiospasm with a dilated pouch above it which would hold more than his stomach, by dilatation with the Plummer apparatus. He remained well for some months until bandits robbed the bank where his entire savings were deposited, whereupon the shock at once brought about a return of his spasm and he had to return for further dilatation which was successful.

Some years ago from a study of 100 cases of cardiospasm I traced four groups of causes or exciting factors. One of the groups were those cases caused by nerve strain or psychic shock, but the point that I wish to make is that, regardless of the etiology, after a cardiospasm has once developed the only cure is by mechanical dilatation. I do not recall but one case which was cured without applying this method.

DR. SMITHIES: I would just like to ask Dr. Winkelstein if he makes a differentiation between spasm at the cardia and cardiospasm, on the basis of permanent esophageal retention. We draw it on the basis of retention for one hour, where there is a retention after a period of one hour after atropinization.

DR. E. B. FREEMAN: For many years I have been very much interested in chronic cardiospasm. I have now studied more than 100 cases, and I have not been impressed with psychic disturbances as an etiological factor in the cases that have come under my observation. I believe that so-called chronic cardiospasm is due to disturbance in the neuromuscular mechanism of the esophagus or diaphragm, secondary to organic disease.

Very few pathological studies have been made in chronic cardiospasm. Dr. Rake,

however, has recently reported a small number of cases in which the autopsy findings showed definite degenerative changes in Auerbach's plexus. These changes he thinks are sufficient to produce the condition. Mosher and McGregor have reported similar findings in 1 case. Dr. Vinson of The Mayo Clinic reports that they are now studying the autopsy material from 10 cases, but are not quite ready to report their findings.

DR. ASHER WINKELSTEIN, (closing): It should be emphasized again that this paper is not an attempt to explain transient spasms of the esophagus or cardia but true cardiospasm.

How large the group with psychic factors is I do not know. It is not necessary to assume that the cause of the disease is the same in all cases. Psychic factors should be thought of especially when nothing definite is found to explain the condition.

Dr. Emmeter's interesting group consists in patients with intermittent spasms of the cardia on a psychic basis. This group may merge with the group presented here in my paper.

With reference to Dr. Freeman's remarks on the importance of histopathological changes in Auerbach's plexus, it should be recalled that Hurst stated definitely in his writings on the subject that these changes impressed him as being secondary. Often, in the dilated esophagus, there occurs an esophagitis. The inflammation affects Auerbach's plexus and this may play a secondary rôle in the disease.

We are completely in accord with Dr. Verbruycke's opinion that mechanical dilatation is usually the best form of treatment in the old, chronic cases. Psychotherapy may be very helpful early in the disease and possibly also later in conjunction with mechanical therapy.



# DIVERTICULUM OF BLADDER HERNIA\*

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OUTSIDE of freak or congenital conditions where the liver, spleen, stomach and other abdominal organs have been found in the inguinal canal, hernia of the bladder ranks probably second to the more common epiplocele or enterocele. Giving the bladder hernia second place does not mean to say that it is frequent. In the past two hundred years, only about 200 cases have been reported. The first reported is probably that of F. Plater of Basle in 1550; the second case by Jean Sala in 1620. It has been estimated that bladder hernia occurs in less than 0.5 per cent of all herniae. It is found so infrequently that the highly desirable preoperative diagnosis is rarely made, and the bladder is often opened during operation with disastrous results.

*Etiology.* Many causes have been mentioned to explain its formation such as prevesical fat, weakened abdominal wall, either congenital or acquired, abdominal trauma, marked distention of an obstructed bladder, diverticulum or flaccidity of the bladder wall, pregnancy, obesity, old age and debilitating diseases. Age and changes within the bladder wall itself are probably more the causation of bladder hernia than any other factors. Baker, quoting Caley, found that they occurred more commonly in the male between fifty and sixty and in the female between thirty and forty. Oliva likewise agreed that bladder hernia is associated with old age and states that there are only 16 cases of bladder hernia in children reported in the literature. Pregnancy, perineal laceration, and cystocele are more than probable factors in the causation of bladder hernia in women. Bladder obstruction with marked distention places an additional strain upon the abdominal wall or an atonic bladder with marked flaccidity offers the chance

of its wall to be pushed through a hernial ring.

*Pathology.* The bladder hernia may be inguinal (direct or indirect) or femoral. The femoral type has been said to be the most frequent in women, but in my 2 cases they were in the inguinal canal, and strange to say, they were both on the left side. Bladder herniae are not true herniae in the sense that they are found in a peritoneal sac. Jaboulaz and Villard are credited with classifying them as intraperitoneal, extraperitoneal and paraperitoneal depending upon whether the bladder is within, outside or beside the peritoneum. In order of their frequency, paraperitoneal comes first, then intraperitoneal and lastly extraperitoneal. If we recall the relation of the bladder to the peritoneum, we can easily see the difficulty or impossibility of finding a true hernial sac. If a true sac is present, it will be found that the neck of the true peritoneal pouch directs its pedicle away from the midline, whereas if the sac really consists of the bladder or a bladder diverticulum, its pedicle is directed toward the midline. According to Heineck, the spermatic cord usually lies to the outer side of the sac, may be spread over, behind or below and external to the sac.

Pathological findings in the bladder itself are not constant. The bladder may be thin or thick. The herniated portion may be a part of the bladder proper or a diverticulum.

*Symptoms.* The patient may not complain of any symptoms except those common to enterocele. In my case, the patient complained only of the usual symptoms of prolapsus. The bubonocoele was a secondary consideration. Examination of the swelling did not reveal the highly diagnostic symptom of a decrease in the size of the swelling after urination. Heineck and Watson have

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used the term "two-step" urination in which the patient first voids the urine contained in the bladder proper and following this is able to pass the urine which has accumulated in the portion contained in the hernia. Farr and Brunkow reported that the "two-step" urination was not a prominent feature in their patient, but that the patient stated he knew that the bulging was closely related to urination and always found that emptying the bladder was not satisfactory unless he lifted up and pushed on his rupture while voiding. Chronic cystitis and also painful micturition may be prominent symptoms. A severe constant pain from a mechanical cause may be present as in any other case of strangulation.

In symptoms, we have but one symptom that is really of value in arriving at a preoperative diagnosis and that is, a bubonocoele that disappears on urination and reappears when the bladder fills. With this symptom alone, a preoperative diagnosis of bladder hernia or bladder diverticulum may be made.

*Diagnosis.* A definite urologic history is not always obtainable, as some of these patients are emergency cases. The physical findings of bladder hernia, except that the hernia is not reducible, are not differentially diagnostic from the usual herniae. Watson pointed out that a rectal examination in men may be made to determine it if there is an enlargement of the prostate with bladder obstruction and overdistention. In females, one may readily see that the woman has a cystocele, and with a mass in the inguinal region that is not gland enlargement, a bladder hernia may be suspected. If the bubonocoele decreases after urination, it is quite certain that the bladder is sure to be present in the canal. Another diagnostic point mentioned by Heineck is that in bladder hernia, after reduction, there remains a "doughy mass" which is probably the prevesical fat. A non-reducible hernia suggests the possibility of bladder hernia. In non-emergency cases, when the examining surgeon is not

satisfied that the bulging mass presents all the usual characteristics found in the common form of hernia, a cystoscopic examination should be made. The bladder should be filled with either air or an opaque solution, and an x-ray picture will give a positive diagnosis of bladder or diverticulum of the bladder in the inguinal or femoral canal.

*Treatment.* The treatment is surgical. It may be an immediate operation or a postponement of the operation, depending upon complications. Among the complications which are commonly found are strangulation, calculi, cystitis, or an omental or intestinal hernia. Strangulation must be treated immediately, as in every strangulation, but a correct preoperative diagnosis is desirable, if it is possible, as it may prevent injury to the bladder. Cystitis is a frequent complication and was found in a number of cases. In my cases, it was present in a very mild degree, which is common in long standing cystoceles. If we have made a preoperative diagnosis of bladder hernia, it is obvious that before operating, the cystitis should be under control and the urine sterile.

I shall not speak of the usual methods of handling hernia cases, the closure, etc., but shall speak more particularly of the case I had recently, which was a diverticulum of the bladder.

#### CASE REPORT

Mrs. F. M., aged thirty-two, previous history unimportant. Patient had one child thirteen years ago, no miscarriages. Appetite poor, there was pressure on micturition, bowels constipated. Menstrual history: last menstrual period September 17, always regular, flowing about seven days, painful first day. This pain had been present since the birth of her child. Examination showed a marked relaxed perineum, a large cystocele, extreme retroflexion of the uterus with a second degree of prolapsus and a small hernia on the left side which was not reducible.

*Operation,* Nov. 8, 1929. An interposition operation was done. The patient and also her family physician requested that the hernia be

repaired. After finishing the interposition operation, I proceeded to do a hernioplasty. After getting down to what was thought to be the sac, I noticed a protrusion of fat, adherent to the external ring that bled rather profusely. This put me on my guard and I felt sure the hernia was not intestinal but bladder. I opened the peritoneum just a little below the internal ring, and placed my forefinger into this opening and I located the bladder. A slight pull on the structures that were protruding through the external ring showed that it was connected to the bladder wall. The peritoneal incision was enlarged and retracted and I could plainly see the bladder, and from the upper lateral left wall of the bladder, an elongated neck extended outward through the external ring. The peritoneum was closed and the protruding mass was dissected and freed from the ring. After it was freed, I was able to withdraw the protruding mass about an  $1\frac{1}{2}$  or 2 in. outward. I made an incision into the mass and found it to be empty. The wall was thick and had the appearance of bladder mucosa. I could not see the inside of the bladder as there was a marked constricted area about  $1\frac{1}{2}$  in. from the outermost part. A small probe was passed down the canal which was followed by a long aspirating needle that was attached to a 25 cc. syringe and the fluid that was withdrawn proved to be urine. The mass was further withdrawn, and between two clamps, the diverticulum was excised. A purse-string suture was placed around the outer portion of the neck of the stump and inverted as one would do in the removal of an appendix. Several layers of No. 1 chromic catgut sutures were placed over this and the whole mass was returned to the peritoneal cavity. A mushroom catheter was passed through the urethra into the bladder. The abdominal wound was not drained. Through the mushroom catheter, the patient's bladder was irrigated every four hours with normal saline solution. For the first three days, blood-colored urine drained through the catheter. Her temperature rose to  $101^{\circ}\text{F}$ . twenty-four hours after the operation and remained between  $100^{\circ}\text{F}$ . and  $101^{\circ}\text{F}$ . for the next few days; pulse ranged about 90 to 100. After the fourth day, her temperature dropped to normal and remained normal throughout her convalescent period. Bloody urine drained for about six days. After the urine was clear, the catheter was withdrawn.

The patient left the hospital twenty-one days after the operation; perineum and abdominal wound had healed perfectly. Patient was seen on March 1, 1930 and a cystoscopic examination was made. The bladder mucosa was normal in appearance except for a slight puckering in the upper left corner. The abdominal wall was firm and there was no return of the hernia.

The other case I saw about ten years ago, and in this one, it occurred in a female with much the same symptoms as the first woman had had. She had a prolapse, a large cystocele and a left inguinal hernia. An interposition operation was done first and then a hernioplasty. She was fifty-five years of age. In this case, I did not recognize the bladder and cut into it. Fortunately, the urine was not infected, but the wound broke down and there was a recurrence of the bladder hernia which had to be repaired later. The result of the second operation was not entirely successful. I saw her about five years afterwards and made a cystoscopic examination. The bladder showed a marked reddening in the upper left corner. This was treated with nitrate of silver and after five or six treatments, this gradually improved and since then I have not heard of the patient.

**Prognosis.** There are no satisfactory statistics on the prognosis of bladder hernia. Surgeons have had but few cases, and not enough to estimate mortality in this form of hernia. Some have estimated it to be as high as 15 or 20 per cent. This high estimate is probably based upon the accidental opening of an infected bladder, old age, obesity and other associated debilitating conditions.

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# IMPLEMENTS FOR FOOT AND HAND INJURIES\*

H. C. MASLAND, M.D.

PHILADELPHIA, PA.

IT is not uncommon to see feet that are permanently deformed and disabled due to the fact that fracture deformities

just above the distal heads of the metatarsal and metacarpal bones. These clamps grip the anterior and posterior portions

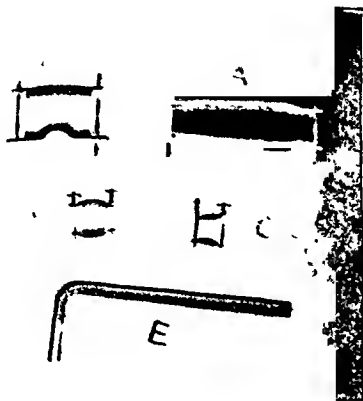


FIG. 1. A, B, C, traction clamps for metatarsal, metacarpal and phalangeal displacements. D, clamp for carpal displacements, E, one of two wrenches for shaping plantar splint B, Fig. 2.

of these bones are assumed to be beyond the possibility of good restoration. After a more or less half-hearted attempt to improve by hand traction and moulding, the member is placed in a fracture box or cast and the bones unite, frequently in an altogether uncorrected position.

The illustrated implements are primarily for the immediate correction of bone deformities of the hands and feet. They are practically of the same construction. They consist of steel bars, covered on their skin-bearing surfaces with cushion rubber. A, B, C, Figure 1, are for metatarsal, metacarpal and phalangeal traction. B and C, are clamps that can be tightened by the side screws to a sufficient and non-slipping grip upon the anterior and posterior surfaces of the digits. The smaller clamp, will grip the last phalanx of the little toe to correct a dislocation or an overriding fracture of an upper phalanx. The larger clamp, B, is for the thumb or the great toe. The clamp A, will grip two or more of the fingers and toes. It can also be placed



FIG. 2. A, traction clamp engaged above distal ends of metatarsal bones B, padded metal plantar splint. The cast is not padded.

with lessened pressure upon the laterally placed vessels and nerves.

The heavy pressure of the clamps necessary for the reduction is neither necessary nor would it be safe for the subsequent retention and the treatment of the injury. The pressure must be reduced till there is a restoration of comfort and circulation. As a general rule, I advise replacing the clamp with adhesive plaster traction after the reduction is secured with the clamp. Many fractures of the finger phalanges can be treated subsequent to the reduction with a simple guttered splint. For the others, unpadded plaster of Paris casts give the counter pressure for the traction. These extend more or less over the limb from above the upper fragment of the fracture. A plate with two projecting screws is imbedded in this cast. For the hand it is upon the dorsal surface; for the foot it is

\* Submitted for publication August 20, 1930.

upon the sole of the heel. A splint, slipped over the projecting screws extends beyond the digits, where it ends in a cross piece to which the traction cords are attached. Figure 2 shows the construction for fractures of the metatarsals. The cast includes the tarsal bones. The extension splint, B, Figure 2, is bent to preserve the plantar arch. It is placed toward the inner side of the foot to hold the maximum arch of the foot. With the wrenches, E, Figure 1, the splint strips can be bent and twisted as desired. Under the arch the splint arm is suitably padded. As foot injuries are prone to much swelling, the leg cast is split before it becomes hard. It can be held open with appropriately sized rectangular cork wedges to meet this contingency. In the retention treatment,

the clamp gives more direct bone traction than adhesive plaster. If used it should be watched carefully, and at the first sign of irritation should be replaced with the adhesive plaster.

D, Figure 1, is used in the correction of displacements of the carpal bones. The rubber padded convex surface is applied to the palmar concave arch of the wrist. With powerful pressure, the bone is driven in while at the same time the intercarpal spaces are opened transversely. To and fro flexion of the hand will tend to open these spaces longitudinally. It is not assumed that this will correct all of these deformities. I do believe it more efficient than any other non-operative method described in the literature. It should be given a trial before operative interference.



## A NEW AND IDEAL METHOD FOR INJECTIONS OF IODIZED OILS AND OTHER FLUIDS IN THE LUNGS\*

ARNOLD JOSEFSON, M.D.

STOCKHOLM, SWEDEN

IN 1925 I showed a very simple method for filling the bronchi and the lung with lipiodol. I used a cannula tongue depressor, to which I directly fixed the top of the syringe, containing the oil.<sup>1</sup> The cannula tongue depressor adapted itself to the whole tongue, while its tip became engaged in the epiglottis. After anesthetizing the tongue and the larynx I gently held the tongue with one hand and with the other held the instrument. Without a headmirror, I easily made the injection in the dark.<sup>2</sup>

Some weeks ago I showed the Swedish Association of Medicine how it is now possible to make the injections quite as



FIG. 1.

<sup>1</sup> *Terapia contemporanea*, 1926.

*Schweiz. med. Wchnschr.*, 1926.

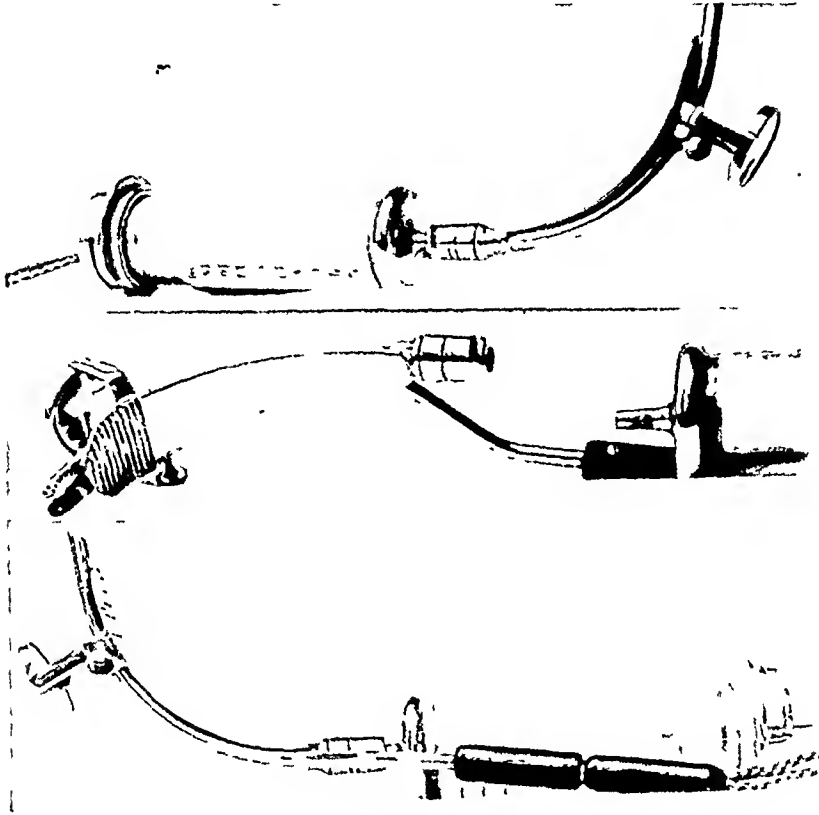
*Allm. sensk. läkartidningen*, 1926.

<sup>2</sup> In the *AMERICAN JOURNAL OF SURGERY*, 8: 2-2, 1930, I find that Soresi has described a syringe of quite the same construction as my old one.

\* Submitted for publication May 29, 1930.

simply as before *but in full light*. I have fixed a common laryngeal mirror on my syringe, on which I also have an electric

easily filled a cavity in the upper part of the lung and after leaning the patient on the side I also showed how the form of the



FIGS. 2, 3 and 4.

light. Figure 1 is an illustration of the first case in which I made use of my new cannula depressor. I have in this case very

cavity changes with the altered position of the patient. Figures 2-4 show two views of my new cannula tongue depressor.



# The American Journal of Surgery

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## EDITORIALS

### APPENDICITIS

JUST when one thinks the problem of appendicitis has been settled a new angle presents itself that calls for thought. In the *Weekly Bulletin of the New York Department of Health* (Feb. 21, 1931) are some interesting figures. We take the liberty in quoting from the article:

#### APPENDICITIS—AN IMPORTANT HEALTH PROBLEM

An excellent statistical analysis of the death rate from appendicitis in the United States by Dr. Frederick L. Hoffman has just been published in the *Spectator*. This gives some startling information regarding not only the increase of the death rate from appendicitis in the United States, but as to the rather disconcerting position which the rates in this country (and Canada) occupy in the tabulations of the various countries.

So far as this last point is concerned, Hoffman gives the following table for twelve European countries:

#### APPENDICITIS DEATH RATES—EUROPEAN COUNTRIES, 1921-28 (PER 100,000)

Spain.....	2.8
Italy.....	2.9
Holland.....	3.5
Norway.....	5.4
Irish Free State.....	5.5
Germany.....	6.6
England and Wales.....	7.1
Belgium.....	7.2
Northern Ireland.....	7.2
Sweden.....	8.6
Scotland.....	9.7
Switzerland.....	10.4

Combining the figures for these twelve countries, which in 1928 had an aggregate

population of 207 million inhabitants, it appears that the average appendicitis death rate for European countries is 5.6 per 100,000.

In the United States the deaths from appendicitis were in 1927, 17.5; 1928, 17.8; and 1929, 18.00, per 100,000.

An interesting aspect of the appendicitis mortality is the consistent excess in the number of deaths from appendicitis among men as compared with women, an excess met with, according to Hoffman, practically throughout the world. In the United States in 1920 the male death rate was 15.1 per 100,000, while the female death rate was only 11.3. In England and Wales in 1928 the male death rate was 8.6 and the female death rate was 6.0.

Hoffman calls attention to the rarity of appendicitis in the British tropical colonies and cities an interesting discussion on Diet and Appendicitis with particular reference to primitive people, by Dr. W. Shrubshall, appearing in the *British Medical Journal* of March 30, 1930. After commenting on the extreme rarity of appendicitis in the Bantu race in South Africa, Shrubshall says:

"The natives regard themselves as being constipated if they do not go to stool at least twice a day. Quite commonly they go out three or four times in the course of the day. In this connection it is to be noted that in their squatting attitude while at stool they employ the pressure effect of the muscles of the abdominal wall to the best advantage. The comfortable water closets of civilization do much to minimize the valuable aid of these muscles."

With reference to meat, he states:

"While it is true that the natives are exceedingly fond of meat, it is equally true that they very seldom have it in ordinary circumstances. They are not regular meat eaters, and the total

quantity eaten by the average native in the course of a year is very much less than that consumed by the average European . . .

"Thus there are in the life of the Bantu people three important factors which, theoretically, at least, militate against the onset of appendicitis: (1) frequent and regular evacuation of the bowels, (2) the absence of much meat in the diet, and (3) the presence of abundant cellulose in the every day food. These people do not suffer from appendicitis, and, moreover, they are not afflicted with gall-bladder affections."

In order that our readers may have a clearer idea of the significance of the prevailing death rates from appendicitis in this country in recent years (from 15 to 18 per 100,000), the following tabulation of death rates for some other common causes of death in New York City is given:

DEATH RATES PER 100,000, NEW  
YORK CITY, CERTAIN PROMINENT  
CAUSES, PAST SIX YEARS

	Deaths per Year	Rate
Measles, scarlet fever, diphtheria and whooping cough (together) . . .	1075	16.18
Automobile accidents. . .	1164	17.25
Diabetes . . . . .	1564	23.54

This tabulation shows that the present death rates from appendicitis deserve the most careful attention of physicians, surgeons and health administrators. Information must be obtained as to the reason why European rates are so much lower than those in this country; why they are higher in males than in females; what part, if any, our diet plays in the matter. Dr. Hoffman deserves thanks for his stimulating analysis.

T. S. W.



## THE LATERAL POSITION FOR BED PATIENTS

PROBABLY few surgeons are unacquainted with the practical value of frequent change of position as a means of reducing the danger of post-operative hypostatic pneumonia. In many hospitals it is a matter of routine that surgical cases as well as aged or weakened medical patients are given the benefit of

this prophylactic measure, the object being to improve circulatory conditions of dependent portions of the lung, to lessen difficulty of coughing up mucus, etc.

Ordinarily the half-sitting position is employed, with a mechanical head rest, but this is uncomfortable when kept up for any length of time, tiring the patient



and causing stiffness in the hips, and with the drawback that one tends to slip down in the bed; and at best the sloping portion of the chest is raised very little.

Baastrup\* calls special attention to the value of the lateral position, allowing patients in danger of hypostatic congestion to lie, morning, noon and evening, for half an hour on the right side and for half an hour on the left side. Viewing the matter from the standpoint of the radiologist Baastrup enumerates the following arguments:

By carefully controlled calculations based upon roentgenograms made in the right and left lateral positions the left lung shows a surface between one-fourth and one-third larger when the subject is lying on his right side than when he lies on his left side; and, conversely, the right lung is about one-fourth larger when he is lying on his left than when he is lying on his right side.

If one attempts to calculate the cubic contents of the lungs, the difference between the figures will, of course, be still greater because it is the broader medial walls of the lung spaces that move inward.

The measurements of the surface of the lungs, as projected with the subject respectively in the right and left lateral position in one of Baastrup's subjects follow:

Left lung in right lateral position: 213 sq. cm.

Left lung in the left lateral position: 155 sq. cm.

Right lung in right lateral position: 190 sq. cm.

Right lung in left lateral position: 236 sq. cm.

These figures together with the observation that the lung on the down side always appears definitely darker as compared with the upper one, show the very considerable extent to which the bulk of the nether lung is compressed and that of the upper expanded. To this must be added the massaging action which the pulsation of the heart exercises on the nether lung, and finally the temporary shifting of the blood's own weight, important since the weight and constant stagnation of the fluid in one place are the principal causes of hypostasis.

Experience with Sante's maneuver in the treatment of acute postoperative pulmonary atelectasis, placing the patient in the lateral position with the sound side down, confirms Baastrup's observation that mucus from the right bronchi will be more easily gotten rid of when the patient lies on the left side, and from the left bronchi when he lies on the right side. Indeed, the employment of the lateral position as a routine prophylactic measure after operation combats not only hypostatic congestion but also any tendency to atelectasis.

The author calls attention to the fact, already well known to radiologists, that the stomach evacuates its contents much more rapidly when the patient lies on the right side than when he lies on the back or on the left side.

JAMES T. CASE



## BRITISH LETTER

ON January 21 last a most interesting ceremony took place at St. Bartholomew's Hospital, when Lord Moynihan of Leeds, the President of the Royal College of Surgeons, handed to Sir

D'Arey Power on behalf of his friends and admirers, a volume of his own "Selected Writings" which had been collected and prepared by members of the Osler Club and published by the Oxford University Press to commemorate his seventy-fifth birthday. The presentation took place in the great hall of St. Bartholomew's, where a numer-

\* Baastrup: The prophylactic and therapeutic value of the lateral position for bed patients. *Acta Radiologica*, 22: 23, 1931.

ous company had gathered in his honor. Apart from his works and writings for the advancement of surgery, no man has done more in this country to interest his professional brethren in the historical aspect of surgery. Sir D'Arey has an unrivalled knowledge of the lives and works of the master surgeons England has produced, as may be assumed from the fact that he has contributed some 185 articles relating to members of the medical profession, whose life and work have entitled them to a place in the "English Dictionary of National Biography": and since the inception of the *British Journal of Surgery* in 1913 there is hardly a number which does not contain some contribution from his pen in the nature of a biography of some famous surgeon of bygone days or a short account of some epoch making book. His edition of South's "Memorials of the Craft of Surgery in England" published in 1886 by Cassell & Co. is one of the most valuable contributions to the history of English surgery we possess and might truly be described as a mine of information, but so far as I can gather it has never been read by the profession at large to the extent it so richly deserves. In short it recounts the business, the corporate life and government of those who in successive ages practiced the art and craft of surgery; and as the late Sir James Paget said:

The reader may trace therein the progress of medical education onwards from the teaching of apprentices, who were to be comely and to be able to read and write, and to wear no beards, and to be well punished for their faults; or the progress of the teaching of anatomy from the custom of public demonstration once or twice a year onwards, to the methods of our medical schools.

Further, "it tells of the acquirement and defence of civil rights, the maintenance of dignity and discipline, the repression of rivalry, the settlement of disputes" and of the general desire of those having authority in the craft to promote the advancement of surgical knowledge.

His "Life of William Harvey" published

in 1897 in the Master of Medicine Series (Unwin) is a complete and fascinating study of this most famous of all British physicians. Harvey himself obtained the reversion of the post of physician to St. Bartholomew's Hospital in 1609, and retained this appointment until 1643. Of this foundation of Rahere and its glorious past with its long array of famous physicians and surgeons, Sir D'Arey had made himself the historian, and imbued with the tradition of the place from almost a lifetime's association, he has written its story in a most thorough and attractive way.

The "Selected Writings" in this commemorative volume include some fourteen articles on historical or biographical subjects, amongst others a brilliant essay on Harvey's travels on the European Continent, when he accompanied Thomas Howard, Earl of Arundel, who was sent by Charles I to Vienna as Ambassador Extraordinary to the Court of the Emperor Ferdinand II; he, however, quitted the mission for a time and proceeded south as far as Rome: An address he gave at Baltimore in 1924 on "How the tradition of British Surgery came to America": A very concise history of the Royal College of Surgeons from its inception in 1800 to 1900, full of interesting facts relating to the development of surgery during the past 100 years. The story of the education of a surgeon under Thomas Vicary is a most entertaining account of the apprenticeship, education and methods of our predecessors of the 16th century. Vicary himself was Sergeant Surgeon to Henry VIII and proved himself to be a man of integrity, skill and judgment, as may be gathered from the fact that he set himself the task of raising the standard, not only of surgical knowledge but of professional conduct, and, with the aid of a group of friends equally zealous of the craft which they adorned, met with some considerable measure of success.

These four essays are sufficient to indicate the trend of Sir D'Arey Power's work generally, but a reference to the biography of his writings at the end of the volume,

tabulating some 600 various contributions to the medical press, show him to be a man of extreme culture, with a profound knowledge of the history of surgery, and no mean contributor to contemporary surgery. May we hope that he may long be spared to continue his researches and further enrich our history with many more erudite sketches from his pen.

It was the privilege of a St. Bartholomew's man to give the Vicary Lecture<sup>1</sup> at the Royal College of Surgeons on November 6, 1930. On this occasion Professor Gask took for the subject of the lecture "Vicary's Predecessors" and he has succeeded in tracing from various records the names and services of those who had held the office of King's Surgeon before Thomas Vicary, a task which has been undoubtedly very difficult and demanded a very laborious search of the various Rolls which are more or less records of the transactions of the early Kings of England, written on parchment, sewn end to end, and then rolled up; but Gask has succeeded in rescuing from oblivion a series of surgeons from the time of Edward the Confessor, who were chosen to attend their Sovereigns in peace and war, and has given us whatever notices of them that could be found, their services, emoluments and rewards. It appears that Master Henry de Saxeby, in the reign of Henry VII, was the first surgeon to carry the title of Sergeant Surgeon, the appointment dating 1251. Professor Gask says that it seems probable at this time the description meant that such an one was attached to the King's person and received grants of land or livings in lieu of wages; later it appears to have meant that, when more than one surgeon was attached to the Monarch, the senior of them was termed "Sergeant Surgeon" and was responsible to the King for the surgery of the Court, and for providing and keeping the necessary drugs. Be this as it may, Master Henry de Saxeby seems to be the first of the long line of surgeons which came down through Thomas Vicary,

<sup>1</sup> *Brit. J. Surg.*, 18: 479, 1930.

and is continued to this day in the person of Sir Hugh Rigby Bart, K.C.V.O.

In the last twelve months much progress has been made by the British Radium Commission in organizing Radium Centers. Practically all large provincial towns having Medical Schools are to be allotted a certain amount of radium according to their needs, and they are to be helped and encouraged to provide the necessary facilities for research work. In the London area those hospitals first in the field in radium therapy, particularly the Middlesex, Westminster, St. Bartholomew's and the London, are now well provided with supplies of radium, and the Commission have granted an amount of radium, namely 4 gm. to the Westminster Staff, in order that they may try out Curie-therapy at a distance from the skin. This apparatus has been constructed and installed in an annex to the Westminster Hospital devoted to cancer patients, and a review of the last year's work at this institution is expected in a short time. The Mount Vernon Cancer Research Hospital at Northwood has been established and a group of experts in the various branches of surgery, radiology, pathology, and biochemistry, have been appointed; facilities have been placed at their disposal for the investigation and treatment of patients, and periodical courses of instruction in modern methods of treatment are to be undertaken by the members of the staff.

Mr. H. S. Souttar gives a concise summary of his views on "Radium in the Service of Surgery"<sup>2</sup> in his Schorstein Lecture at the London Hospital in October last. He is convinced that in radium we have a weapon of extraordinary power in the treatment of cancer, but we are still far from knowing all its possibilities or from being able to direct its energies to the best advantage. One great difficulty is to obtain uniformity of radiation; the bomb gives this but the wastage of material is too great and the power of damaging the tissues implies skill which is not generally

<sup>2</sup> *Brit. M. J.*, January 3, p. 1, 1931.

available, so that he suggests uniform infiltration as more likely to lead to practical results, since here the whole of the energy of the radium is utilized instead of a minute fraction, and he is endeavoring to devise methods by which still smaller seeds can be produced so that the whole volume of the cancer may be literally peppered with minute foci.

On the biochemical side he thinks it does not seem impossible that some method might be devised for sensitizing the tissue of a tumor and points out that this is more likely to be effected by stimulating its growth than reducing its vitality, thus bringing about more active mitosis in order to render the cells more vulnerable.

On the clinical side he considers more might be done to protect the normal tissues upon which so much depends for success. He emphasizes the importance of adequate protection of the skin, which he achieves by soaking it in some simple ointment, and the one he strongly advises is a mixture of equal parts of zinc oxide ointment and castor oil. He maintains that under this treatment the skin reaction is so greatly diminished that there is no fear of any serious dermatitis.

The lecturer's remarks on the treatment of cancer of the rectum are of great interest in that he considers this region is peculiarly adapted to the use of seeds, whether the growth is within reach of the anus or can only be reached from the abdomen. The technique is very simple. With the patient in the lithotomy position the needle of the introducer is inserted to one side of the tip of the coccyx and 15 platinum seeds of 2 millicuries each are introduced in long columns and uniformly deposited first on one side and then the other side of the rectum. By this means, in the case of a posterior growth, a substantial barrage of radon irradiating the growth and the rectal glands is provided. The infiltration of an anterior growth is more difficult; if the growth is at a high level it must be exposed by laparotomy and seeds then introduced across the peritoneal cavity; this, of course,

entails a permanent colostomy. He believes that cancer of the rectum is very sensitive to radium and a localized tumor may disappear with great rapidity, while even in advanced cases the insertion of radium or radon may make it possible to remove a growth previously inoperable; the only difficulty is that the rectal mucosa is itself highly sensitive to radiation, and great caution in dosage is therefore necessary since an excessive dose may produce a severe proctitis. These views of Souttar's are encouraging, although in many respects they differ from the French School led by Regaud.

Dr. Laeassagne,<sup>1</sup> speaking last year at a discussion of radium in the treatment of rectal cancer at the Royal Society of Medicine, said that in the work at the Radium Institute of Paris, under the direction of Professor Regaud, neither the present methods of radium therapy nor the older ones had enabled them to bring about a cure of rectal cancer, which appeared to them still to belong to the domain of surgery. The failure of radium to effect a cure was on account of the low radiosensitivity of adenocarcinomas of the rectum. Sir Charles Gordon Watson who opened the discussion, and who has done pioneer work in this form of regional surgery in London, concluded his general statement with the following observations:

(1) In young people, in increasing ratio, from the age of forty years onwards, rectal carcinomas grow rapidly, metastasis occurs early, and the end-results of radical surgery are not good. An actively growing carcinoma in a young subject responds well to radium, far better than does a slow growing carcinoma in an elderly subject, but evidence as to end-results, in comparison with those of surgery, is not available.

(2) If a growth is adequately barraged with radium and shows little evidence of retrogression after two months, it is probably useless to repeat radiation. On the other hand, if the growth responds to radium and retrogresses, though it fails to

<sup>1</sup> *Proc. Roy. Soc. Med.*, 23: 1465, 1930.

disappear completely, further radiation is indicated, on the ground that the dose has been insufficient in respect of amount, time or distribution.

(3) Secondary radiations are less likely to produce a good final result than are adequate primary radiation, and are more likely to produce pain of a neuralgic type which may be very severe and may last for long periods.

(4) When the growth has been exposed by an open operation an overdose may result in perforation of the bowel, with secondary sepsis, and when healing takes place it may be followed by excessive fibrosis and consequent stricture.

(5) The criteria of a correct dose are (a) absence of sepsis, (b) a well marked radium film, (c) rapid resolution of growth, (d) restoration of normal epithelium and (e) limited fibrosis.

(6) Radon is less efficient than radium, but is valuable within the abdomen, and within the lumen of the rectum.

(7) Apart from the possibilities of cure, radium has its value in improving both the local and general conditions of an inoperable case, so that in some instances

operation, with prospect of a cure, becomes possible. In cases of local recurrence after excision it is an asset of great value if the recurrence is treated early. It gives help to those who are beyond surgical help, and in moderate doses has a remarkable tonic effect on the general health.

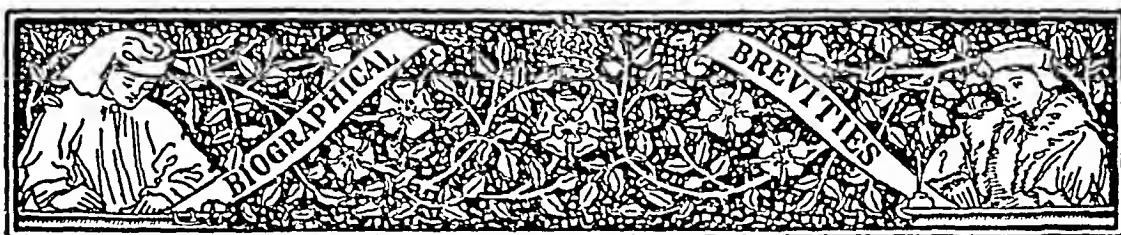
He further maintains that the treatment of cancer of the rectum with radium is still in the nursery stage. Time will show whether selection, combined with increased experience and skill, will vastly improve results in radium therapy, or will reveal that radium is too capricious a master, and too seldom a servant, to be reckoned with as a serious fighting factor in the campaign against cancer. Research on radio resistance and methods of sensitization is an urgent need.

Finally Sir Charles declares himself convinced that, "if brilliant results can be secured with radium in a small percentage of rectal carcinomas, further research, increased experience, better technique and great skill will reduce the failures and add to the successes."

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## “MALPIGHIAN BODIES”

**M**ARCELLO MALPIGHI, one of medicine's greatest names, was born in 1628. He is one of the pioneers of microscopy, and the founder of histology.

Malpighi was professor of anatomy at Bologna, Pisa, and Messina. He was physician to Pope Innocent XII from 1691 to 1694.

He won wide recognition, much of which has come down scientific channels to the present time, as a biologist, having done gigantic work on the anatomy of the silk-worm and the morphology of plants.

Malpighi's researches in the embryology of the chick and the microscopic anatomy and physiology of the glands and viscera set him apart from his fellow men. It is all the more remarkable when one considers the tools at his command compared to present-day laboratory paraphernalia.

In his Royal Society memoirs, “*De formatione pulli in ova*” (1673) and “*De ova incubato*,” are twelve plates which place him in the position of the founder of descriptive embryology.

Malpighi described the red blood corpuscles in 1665, but he was preceded in this by Swammerdam by seven years. In addition he discovered the rete mucosum, and proved that the papillae of the tongue

are the organs of taste. It is generally conceded that his most important work is the “*De Pulmonibus*” (1661) which disproved the then held conception that pulmonary tissue was parenchymatous, and proving it to be vesicular in structure. Concerning his discovery of the capillaries (1660) it has been written, “Harvey made their existence a logical necessity; Malpighi made it a historical certainty.”

He devoted much labor to studies of the structure of the liver, kidney, and spleen, and his name has been preserved in the eponym, Malpighian bodies.

In one of his works, he wrote an account of those lymphadenomatous formations which were described by Hodgkin in 1832 and termed by Wilks in 1856, Hodgkin's disease.

In his private life he engaged in a bitter feud with his Pisan colleague, Borelli, and in an ancient feud between his family and a neighboring clan. These facts are interesting only because most of Malpighi's best works were lost to posterity due to wanton destruction in this family warfare.

We read that Malpighi was gentle and fair-minded, and one friend said his memory was one of “sweetness and light.”

Malpighi died at the age of sixty-eight years in 1694.





MARCELLO MALPIGHI

[1628-1694]







[From Fernclius' *Universa Medicina*, Geneva, 1679.]

# BOOKSHELF BROWSING

## THE PRESCRIPTION OF LITERATURE\*

GERALD B. WEBB, M.D.

COLORADO SPRINGS, COLORADO

Says Nature to Physic, what pity that we,  
Who ought to be friends, should so seldom agree.

With medical legions my humours they chase,  
Till pallid resentment appears in my face;  
Aperients, astringents, narcotics, combine  
To thwart and oppose me in every design;  
And by volleys of pills discharg'd at my head,  
My strength is exhausted, my energy dead.  
But Physic should know I am not to be taught  
By severe flagellation to do what I ought;  
That my faults may be mended by gentle  
correction

To which science and talents must give the  
direction.

Nature and Physic—Professional Anecdotes,  
1825.

“HIS blooded, splinted, and strapped, my lord,” says the physician in an eighteenth century story, “so pray do not suffer yourself to worry for him unduly. Everything has been done.” The patient referred to in these words was a young man with a broken leg lying among strangers at a wayside inn; and since this was his situation, it is a fair question whether, despite his being blooded, splinted, and strapped, *everything* had been done. Having thus cared for the man’s body, did the physician then leave him cursing his luck? Or did he make some shift to restore his patient’s mind as well

as his tibia? If the doctor sought also to set the spirit at ease, then I venture to say that he had recourse to literature as speedily as he thought the injured man able to attend to it. For among the many uses of literature not the least is that it may help us to forget our misfortunes, and in especial bring solace to us when we are sick. Accordingly there are many times when it is incumbent on the wise physician to prescribe, not a posset or a purgative, but an essay or a poem.

Perhaps that last statement may seem revolutionary to some members of our profession. Yet, it is not a new idea, and there have been periods in the past when it might even have been taken as axiomatic. Consider, for example, that famous writer and physician, Francis Rabelais. Besides being one of the earliest physicians to demonstrate anatomy by dissection, and besides being the inventor of a surgical instrument (the glottotome) wherewith he cut the tongue-tie of an inarticulate woman, Rabelais was, so far as I have been able to discover, the first physician whom we know to have prescribed literature to his patients. On the title-page of his books, and books were scarce in his day, he wrote in Greek, “The property of Francis Rabelais and of his friends.” Curiously, on the

\* An address delivered at the banquet of the Association of American Physicians, May 6, 1930.

title-page of his\* Aldine Plato the latter part is changed to read, "and of his Christian friends." Is it possible that the latter alone returned the books to the owner?

We have, then, rather good precedent for the suggestion that at times the physician prescribed literature. It is no flighty notion, but sound common sense, such as I like to think was exemplified by the good Rabelais himself in his treatment of the Cardinal du Bellay. This prelate, a friend of the physician, was suffering from a "hypochondriac humour," and requested a consultation of doctors. An aperitive (opening) decoction was prescribed by them. Rabelais, a better diagnostician and therapist than his colleagues who were called in, lit a fire in the yard, placed on it a kettle of water to boil, and filled the kettle up with keys! Asked what he was doing Rabelais replied that nothing opened better than keys. When this merry jest was reported to the cardinal, it produced such a fit of laughter that a cure resulted! This anecdote brings to mind the sending of a patient, by Sydenham, to a fictitious physician in Inverness, and the cure of the patient by *indignation*. And in Rabelais' own immortal book we learn that Gargantua, suffering from insomnia, was put to sleep by a reading of the Psalms! Coriat quotes Rabelais to the effect that the romances of Gargantua and Pantagruel were indeed written to divert and cheer his own patients.

If at first sight literature appear to fall without the province of the physician, let it be recalled that the title "doctor" was originally given to teachers of the liberal arts, and was first employed in its modern sense by Giles de Corbeil to denote the Salernitan masters, who combined sound medical counsel with a flair for poetry. In the Middle Ages the practitioners of medicine had belonged to the *ordo gratiosus*, the beloved order. The word *physician* is derived from the Greek, mean-

ing *Nature*, and as Gairdner has pointed out, we have become designated by the tools of our art (drugs) rather than by the word *medicus* which in its original interpretation meant healing. This has been perhaps unfortunate. In "Pygmalion, or the Doctor of the Future," R. McNair Wilson foresees a great reaction in favor of the doctor, in the older sense of that much abused term. He will be a humanist, with the widest possible understanding of human motives; a cultured man with outstanding sympathy; a lover of the arts as well as a student of the sciences. Wilson looks forward to the time when the practice of medicine will include within its scope, every influence of known potency over the human spirit, and when the practitioner, like Pygmalion, will look on his work and see, not disease and death, but the glowing lineaments of life. It was with this same idea in mind that Clifford Allbutt asked, "What are the most scientific physicians if they know all things save the human heart?" In the same vein Baglivi writes in his "Praxis Medica":

The physician is the servant and interpreter of Nature . . . If anywhere, certainly in medicine, it is required to know much and to do little, especially in acute and complicated cases; and we should try to remove the prejudice of many patients who think their cure depends on the amount and variety of the drugs given them.

"But how can I prescribe more than drugs," I hear one recalcitrant member remarking, "to my patients of average mentality? If the intelligence tests made during the war gave us even approximately true results, and if 40 or more per cent of our citizens are at the mental level of twelve-year old children, how in heaven's name can I suggest books to them? To these the writers of advertisements, the makers of tabloid newspapers, the producers of moving pictures cater; can I recommend anything to such minds?" In reply to such objections, I should say first that the term "twelve-year old intelligence" is misleading to the uninformed.

\* "In Quest of a Perfect Book," by Orcutt, itself a perfect book, contains many interesting anecdotes, including some of Aldus and of the Aldine Press.

Sixteen-year old intelligence is, on the psychologist's scale, the intelligence of genius; ergo, on this same scale, twelve-year old intelligence is not so hopeless as it sounds. And secondly, I should say this: *even eight-year old children read.*

It will require insight to give books to the twelve-year old mind; but it can be done. It will require a knowledge of the field of literature which is not lightly come by; but this can be achieved also. I did not start this paper by saying that what I have to propose would set the physician an easy task; I only say it will set him a worthy one.

The problem of reading for this type of patient is one with which I shall not deal at great length at the present time, not because I think it presents more difficulties, but because my own practice has lain largely with persons who have possessed at least the potentiality of culture, and of them I can speak with more surety. That the higher intelligences present problems in this regard equal to the lower ones, I am convinced. There is a lamentable lack of logic in the best communities, as well as in the community at large, and many educated persons cling to the most absurd teachings. A few years ago a survey in one of our universities revealed, if my memory serves me, that some 30 per cent of the students believed in phrenology and kindred pseudosciences. And I am sure many of us have met otherwise intelligent members of a well known sect that not only rejects medical aid but claims disease is only an error of the mind. Since the members of that sect have asserted that this belief is founded on the Bible, by the way, they should be referred to 11, Chronicles, xvi, 12: "And Asa in the thirty and ninth year of his reign was diseased in his feet, until his disease was exceedingly great: yet in his disease he sought not to the Lord, but to the physicians!" Doubtless it has been the contemplation of such people as these which has led James Harvey Robinson to the melancholy statement that possibly only one in one hundred may

allow his opinions to be altered by assiduous reading, or take pains to cultivate an insight into art and literature and scientific discoveries. With this extreme view I do not hold. Rather do I feel that often lack of time and lack of opportunity are responsible for error, and that illness offers the physician a means for overcoming it that is granted to no other profession. He cannot create intellect, but he can guide it, he can develop its scope, and he can augment the material with which it deals. That is, he can further knowledge and accurate thought. And the way is through books.

Where are your books?—That light bequeathed  
To beings else forlorn and blind!

Wordsworth

Direct your eye right inward, and you'll find  
A thousand regions in your mind  
Yet undiscovered. Travel them, and be  
Expert in home-cosmography.

Thoreau

It goes without saying that if he is to be of much assistance to them, a physician must familiarize himself with the literary pursuits of his patients. Especially is this true for convalescents and those with chronic disease. The greatest alleviation for these may come from a judicious choice of books; but left to themselves the majority of patients will be found occupied with newspapers, magazines, and novels. The deadly sameness of these may not be apparent to the man on his feet, and because of his desultory reading, progress in recovery may be retarded by a discontent which baffles the medical attendant. It is one thing to tell a man to read, however, and another to get him to do it. Suppose, for example, that our young man at the inn is little used to reading. In that event it will be necessary to converse with him at some length in order to find where his interests lie. There are plenty of yachtsmen who never know what a number of books there are relating to their favorite sport; plenty of business men who may be pleasingly surprised to read of their own kind in a history of the East India Com-

pany. Books which deal with already existing interests, then, will generally be best to enlist the sympathies of those who have not the habit of reading. But one thing leads to another, and before your yachtsman knows it, he may be perusing a rollicking yarn about the Spanish Main; while your business man may be engrossed in a historical novel like Feuchtwanger's "Power."

Many times the prescriber of literature may find himself in the situation of Rousseau, when he gave lessons on the flute. Hearing another flutist, Rousseau decided that he would take up the flute and earn money by giving lessons. He started with confidence and kept himself a day ahead of his pupils!

If the patient is led to new interests in this way, one of the great ends of our literary prescription has been achieved. For the most distressing fact of present-day life is that as the world becomes smaller, competition becomes keener and the time allotted to liberal studies becomes correspondingly shorter. For this reason it may often transpire that a long illness may give a man the first chance in his adult life for leisurely reading and thinking. Thus a confinement to bed, by releasing a man from the pace of the world around him, can prove a blessing in disguise. In a recent article Warwick Deeping says of his father a country doctor:

In such a practice as this he might be twelve hours on the road, visiting outlying villages; and yet I have a feeling that he saw more than the modern doctor sees. He had more time to observe things, crops, birds, trees, and the sky and its moods. He had more leisure to be in touch with his environment. He loved poetry and could quote it while handling his reins.

Against such a man as this, our age militates despite all its wonders, and cannot compensate for his loss. Therefore anything which contributes the leisure for the making of such a one should be cherished. I know many professional men, and among them not a few university professors, who

could greatly profit from a half year's stay in bed! Was it not Huxley who wished "release from distraction and complete freedom from those lethal agencies which are commonly known as the pleasures of society"; and Huxley exclaimed to a friend, "If I could only break a leg, what a lot of scientific work I could do." "The Life and Letters of Thomas H. Huxley" recounts a struggle against ill health in the form of relapsing pleurisy and neurasthenia, which cannot fail to convey courage and determination.\*

But perhaps it is too much to expect the sick room to turn into a college of liberal arts. Even if this is so, the ultimate cultural value of sick-bed reading is for us secondary to its immediate curative effect. Whether such reading results in fixed good habits or not, and obviously in many cases it would be foolish to expect it to do so, the present pleasure which it may give remains of paramount importance. Dr. Johnson's dictum that all reading should be for pleasure is doubly true for the sick; and in the vast storehouse of the world's literature there are books which will give that pleasure to every type of intelligent mind. It is not always easy to find the appropriate works at once; but if one search diligently enough eventually one should find one's treasure. In such a search the physician can be of great help, if he but devote a little thought to the temperamental requirements of his patient.

This question of temperament must be the chief factor in any attempt to prescribe books. Not only will different men need different books; besides that, the same books cannot be counted on to affect all men in the same way. Aristotle, the founder of literary criticism, went to some length to explain the effect of high tragedy; but we cannot be sure that the purging of the passions which he describes will be the result of tragedy on all members of the

\* Borodin, professor of chemistry at the Petrograd Academy of Medicine and Surgery, could only find time to compose music when indisposed, so friends meeting him expressed the wish, not that he was well, but that he was ill (Grace Wilm).

audience. Some men especially those with a fine feeling for the struggle of the drama, will be exhilarated by a reading of "Jude the Obscure"; others will most certainly be depressed by this spectacle of man being overwhelmed by fate. Indeed, I suspect that there are many who might read Hardy with no ill effects when well, who would find him too gloomy when read in a sick bed. Perhaps for most persons it would be safer to prescribe Dickens than Hardy, Galsworthy than Dreiser, Thomas Mann than Arnold Zweig.

It is not merely books that depress, however, which it may seem advisable to keep from some patients. If the emotions are easily aroused, certain works may equally well be prohibited because they stimulate in the wrong way. Offhand, Huysman's "La Bas," a truly remarkable book, does not recommend itself for sick-bed reading; and the same may be said of certain of the works of Anatole France, and even of Balzac, although any of these writers will make excellent reading if the right selection is made. Again, there are persons otherwise stable, who are emotionally upset by some subjects out of all proportion to their ordinary importance. Individual prejudices of this sort cannot be ignored: if the patient feels too strongly about the Church, it will be better not to hand him the ecclesiastical essays of Arthur Machen: if he feels too strongly about the Civil War, it will be better not to lend him a highly controversial biography of Ben Butler.

The Bible has always been and still is the greatest book for the solace of the sick. Some, however, will be found analyzing the history of the Old Testament and wondering where the wife came from that Cain "knew," and why Cain built a city when there were only five people in the world! And as a physician I have been called upon to explain these statements!

In an exquisite chapter of Ecclesiastes, you may read: "And moreover, because the preacher was wise, he still taught the people knowledge; yea, he gave good heed,

and sought out, and set in order many proverbs."

"Wycherley," as Connely states in a recent clever biography, "had learned to patch pain with proverbs."

While occupations, interests, and temperaments differ, yet there are common grounds on which all can meet, and one of these and the most satisfying is the reading of biography. There is nothing so helpful as to read of the struggles and triumphs of successful people. It is not enough for a physician to recommend a certain book; if possible he should bring it to the patient himself. As a result of such kindness the book is apt to be read, and the patient becoming interested, the good effect of the visit is continued until the next when discussion adds again to the value of the visit.

Necessarily the physician must have familiarity with his prescription, for it might not be wise to take "The Life of Romanes," the subject of which probably had a glioma, to a man suffering from brain tumor; or Mrs. Gaskell's "Bronte Family" to those afflicted with tuberculosis. The latter biography is perhaps the most pathetic that can be read, six children perishing from phthisis. But the lives of Emerson, Ruskin and Voltaire who reached advanced age in spite of tuberculosis should prove encouraging. The life of Sir James MacKenzie (Wilson's "The Beloved Physician," the "Life of Pasteur," by Vallery-Radot; and the "Life of Michael Angelo," by Grimm, should prove helpful and inspirational to all. Pasteur triumphed, in early manhood, over an attack of apoplexy; and Michael Angelo did much of his immortal work when handicapped by rheumatoid arthritis.

The reading of one good biography creates a craving for others. For instance numerous copies, from my library, of "The Romance of Isabel, Lady Burton," have been worn out. A lady from New York took pity on my last copy and returned it to me bound in exquisite red leather! The charm and interest of this romance lead to requests for Burton's "Pilgrimage

to Mecca," and for "The Life of Sir Richard Burton." Such continuity of reading is a great satisfaction and should be encouraged. It was upon Burton's return from Mecca, and eight years before he knew of the "Rubaiyat," that he wrote an exquisite gem of oriental poetry, the theme of which was that self-cultivation, with due regard to others, was the sole and sufficient object of human enjoyment. One reads:

"Eat not thy heart," the sages said  
 "nor mourn the past, the buried Past;"  
 Do what thou dost, be strong, be brave;  
 and like the star, nor rest, nor haste."

It is impossible to enumerate the countless biographies which have proved their worth. Among those which have entertained many patients I recall Froude's "Lord Beaconsfield"; Lytten Strachey's "Queen Victoria" and his "Eminent Victorians"; Jeanne Bordeaux's "Eleanore Duse"; M. James's "The Raven," (the story of Sam Houston); E. T. Cook's "Florence Nightingale." For the musical, of whom there are, alas, too few among us, there are Romain Rolland's "Beethoven," "The Creator" as well as his many essays on composers, Newman Flower's "Franz Schubert," Hussey's "Life of Mozart," and Mary Lawton's fine life of Schumann. Heink called "The Last of the Titans." Biographies tend to be large books, and at times the weight of the volume must be considered in the light of the patient's condition. "Every man" saith Seneca, "thinks his own burthen the heaviest." When such extremists are women, "The Life of Marie Antoinette," by Belloc, or "The Life of the Marquise de Lafayette," by Marguerite Guilhou, may bring them comfort; while the trials of some husbands may be alleviated by reading Ludwig's "Napoleon," or the story of Socrates and Nanthippe. Nor should one leave this field without recalling the fine autobiographies which are available, notably those like Trudeau's, Victor C. Vaughns, Goethe's, Benjamin Franklin's or Benvenuto Cellini's.

There may be some minds which may not be harmed by such books as, "Catherine the Great" by Hodgetts, "Lady Hamilton" by Gamlin, "The Immortal Ninon," by Cecil Austin, or "Unruly Daughters" by Noel Williams, and "Lady Mary Wortley Montagu" by Melville, and the story of her extraordinary son in "A Gallery of Eccentrics." Such reading at least is historical.

Biographical writing will be excellent fare for nervous persons who are too easily upset by the things they read. There are other types of literature as well, which may be counted upon to induce calm. For the lover of poetry there is no problem at all; the state of mind which one must bring to the perusal of Spenser or Marlowe or Coleridge is in itself exaltedly calm, and the verse of these men will not disturb it. Readers of poetry, it is true, are few indeed, although, as I hope to point out later, they should be many; but those whose fare must in the main be prose can find prose works which will in general have this same effect. The informal essay from Lamb to Kenneth Grahame is good food for these minds; and perhaps they can be led from the nineteenth century back into the eighteenth and made to develop a fondness for Aubrey or Addison or Steele. Personally, I find Washington Irving one of the most urbane and soothing of writers, and one especially adapted to long hours of reading. There are many others like him, all the way from Thomas Browne to Stevenson, men who, not so much from the things they avoid as from their essential sanity of outlook, make equable reading.

Informative writings may be of much benefit to the kind of reader we are now discussing. There is something placid in facts dispassionately presented; the interest in them is usually intellectual and seldom emotional. Mr. Mencken once advised bored Americans to take up science for a hobby. The idea is a sound one. Our sick man need not limit himself to science as the term is now narrowly used. Any part of knowledge may become his province,



from Mexican archaeology to a history of the English language; and if anyone think that such material must be dry in the presentation, let him read Spinden on Maya art or Jespersen on our tongue. It is a fact that the average text is dull; but almost every subject has scholars who can write interestingly of what they know. It is for us to seek them out, because many who are slow to appreciate literature for its own sake may get from them their greatest enjoyment.

Of all branches of informative writing, that which will probably enlist the sympathy of the greatest number of persons with the greatest ease is nature study. A patient on a trying rest regime, to whom the lights of Broadway had been her only joy, was one day found watching a garden spider. Interest was at once awakened when she was told that this spider would create two webs a day, that the females of some species devoured their husbands after the nuptials (this may have reminded her of life in New York!) and that some spider mothers gave their infants daily sun baths. As a result of this interest the patient soon gave the lie to the lines found in one of Beaumont and Fletcher's plays: "Nature too unkind,  
That made no medicine for a troubled mind." by proving that Nature had given her just that medicine.

How neglected nature study has been in our schools and colleges, pledged as so many of them still are to a traditional curriculum which in many ways no longer deserves the name of humanistic! The study of nature touches man at every point; biographical writing is indeed but a variant of it, and reveals how versed in the knowledge of natural phenomena have been most great men. How wide the implications of this branch of science are, one can learn from a penetrating essay by Dean Inge, in which he upholds the contention that the advance in natural knowledge since the nineteenth century impels us not only to a new view of the origins of life, but to a new ethic as well.

Viewed in this light, how important for our future legislation is nature knowledge among our citizens. And who better than the physician can cultivate the gardens of his patients' minds in respect to Nature, and incidentally develop thereby a better appreciation of his own work. The field of nature literature is vast, and entrance may be made into it by many routes. Among such I should recommend Fabre's works on insects and astronomy, J. Arthur Thomson's "Ways of Living"; F. W. Gamble's "The Animal World," and Lord Grey's "The Charm of Birds." The book by Gamble is printed in the Home University Library which offers a number of scientific works of a popular kind at low prices. Books which picture the romance of scientific achievement like de Kruif's "Microbe Hunters" and "Hunger Fighters" are of great value in arousing interest. It is a far cry from these to such heights as Whitehead's "Science and the Modern World" and Eddington's "Nature of the Physical World," but these heights may be scaled by some.

I cannot leave this subject without a reference to a purely fictitious naturalist who has given me untold pleasure. I refer to Hugh Lofting's character, Dr. Dolittle; and in particular do I recommend the volume of that remarkable man's adventures entitled, "Dr. Dolittle's Voyages." There is a rare treat in store for the person who has not yet read of Dolittle's efforts to learn the language of the shellfish, or of his famous observation of the beetle on Spider Monkey Island! Books like Lofting's bring to mind another sort of nature literature, the type in which a story or personal reminiscence is placed against a natural background which is really the most vital element in the narrative. To this type belong the "Puget Sound Stories" of Emma Lindsey Squiers and the sketches of Herbert Ravenal Sass. It is to many a fascinating kind of writing, one which treats Nature in fiction somewhat as history is treated in the historical novel; but possibly with more truth, for it is

easier to be true to nature than to history. Then there are books, which, because of their fantasy, are universal favorites; such a one is "Alice in Wonderland." There is repeated amusement in refreshing one's "Alice," when ill! Lewis Carroll is inimitable in his satire on literary style; and in "The Hunting of the Snark" his ridicule of all types of people will always amuse.

I have said that I consider the readers of poetry too few. There are those who say that they cannot be increased. Some critics maintain this to be a prose age, one in which it is idle to expect a widespread reading of verse. Whether this be true or not, and I am not at all ready to admit it, it does not apply to our present problem, because the patient is temporarily out of his age. He is free to wander in fields hitherto foreign to him; no longer does his own time restrict him and impinge upon him at every turn. He can bring to a reading of, for instance, the great Hindu ethical poem "The Bhagavad-Gita," of which a new and beautiful translation by Arthur Ryder has just appeared, a detachment it may be impossible for him to attain in his routine life. And in truth if he is led to an appreciation of poetry, it will no longer have its old power to bind and enslave the mind.

Although no anthology is wholly acceptable to any but its maker, anthologies will perhaps offer the best means of initiating the novice into verse. The exposure to a large number of authors and a variety of forms may lead to an interest in a few of them. From the puns and charms of Thomas Hood who, by the way, related his improvement after a doctor's visit when they chatted of literature, to the sublimity of Keats, an infinite variety is to be found. Take, for example, "An Anthology of World Poetry," compiled by Mark Van Doren, wherein all nations are represented. Here one may turn from a sonnet by Petrarch or a lyric by Heine to this from the Greek:

The Swan and the Goose  
A rich man bought a Swan and Goose—

That for song, and this for use.  
It chanced his simple minded cook  
One night the Swan for Goose mistook.  
But in the dark about to clasp  
The Swan in two above the crop,  
He heard the lyric note, and stayed  
The action of the fatal blade.  
And thus we see a proper tune  
Is sometimes very opportune.

And if the patient should prefer this to Petrarchian sonnets, let us not be moved. We can be sure that only a few will attain to an appreciation of poetry as a pure art; but many will find in it lesser values, suited to them and equally lasting. "The Poetry Cure," an anthology by Robert Haven Schauffler, in which different poems are recommended for various mental afflictions is a valuable book both for its selection and for the originality of its approach.

Robert Graves is quoted to the effect that "poetry is no more a narcotic than a stimulant; it is a universal bitter-sweet mixture for all possible household emergencies . . . A well chosen anthology is a complete dispensary of medicine for the more common mental disorders, and may be used as much for prevention as cure."

Schauffler omits, however, Longfellow's "Light of Stars" which has often rendered me great service. Few can escape benefit by reciting to themselves daily such stanzas as these:

O star of Strength! I see thee stand  
And smile upon my pain;  
Thou beckonest with thy mailed hand,  
And I am strong again.

The star of the unconquered will,  
He rises in my breast,  
Serene and resolute, and still,  
And calm, and self-possessed.

Oh, fear not in a world like this,  
And thou shalt know ere long  
Know how sublime a thing it is  
To suffer and be strong.

As Aretaeus said, it is the physician's sad lot to mourn with his patients. Many times have I comforted those under my care with these lines of Ben Jonson's:

the ephemeral. While this is in the main our position, we do not wish to carry it to extremes. Always we come back to the individual prescription, and question: what is best for this patient? If P. G. Wodehouse, that funniest of men, is what the patient needs, by all means give him "Fish Preferred." If a mystery story seems indicated, and many are the intellects which have found relief in them, as for example, Wilson and Balfour, give him Milne's "Red House Mystery," Bailey's stories of Mr. Fortune, Chesterton's "Man Who Knew Too Much" or his stories of Father Brown, Leroux's "Mystery of the Yellow Room," Connigton's "Case with Nine Solutions" or Berkeley's "Layton Court Mystery." If he prefers the type of detective story where a semblance to reality is preserved at the expense of ingeniousness of plot, recommend Fletcher or Crofts. If he wants the sheer thriller, let him pick his own! Even this sort of book can sometimes yield information to the reader, for one may get much history in "The Overbury Mystery" which concerns a famous trial in the time of Queen Elizabeth: Bolitho's "Murder for Profit" and Pearson's books on crime come in this same class. It must be apparent to all, however, that the greatest enjoyment of mysteries will come to those who read them as a contrast to weightier things. All we have just said of short stories applies even more cogently here; it is most easy to become "fed up."

Some patients, far from being depressed by being reminded of their physical misfortunes, actually enjoy a search of literature for symptoms or disease similar to their own. One of my patients discovered correctly from Shelley's lines:

I could lie down like a tired child  
And weep away this life of care  
Which I have borne and still must bear . . .

that the poet had tuberculosis. These lines, by the way, were favorites of Oliver Wendell Holmes who, with his New England contemporaries, is not read as

much today as he should be. Another patient discovered by reading Carlyle's advice to his friend John Sterling that this poet also had phthisis. And recently MacLaurin's "Post Mortems of Mere Mortals" had great interest for a patient who could be trusted to indulge himself in this manner, when he read therein the account of Pepys who had a case of kidney stone similar to his own. We must not forget, however, Jerome K. Jerome's "Three Men in a Boat," where one member had walked into a reading room a happy, healthy man. He crawled out a decrepit wreck, because he had read a medical work and decided he had every disease described except housemaid's knee! "Three Men in a Boat" will refresh any invalid. The first chapter alone should be a cure for hypochondria.

Attending a sick physician I found him, unfortunately a rare exception, reading Shakespeare. A doctor is likely to discuss his hobbies with his patients, so I told him I had often wondered if Shakespeare could be connected with Bacon through Harvey, who had been Bacon's physician. My patient quickly adduced evidence against this by referring me to the Galenic ideas of Shakespeare, where King John, in speaking of the blood, exclaims:

Or if that surly spirit, melancholy,  
Had baked thy blood, and made it heavy, thick,  
Which, else, runs trickling up and down the  
veins.

For recreation in the original sense of the word, have your patients who are interested in Shakespeare read Sydney Lee's biography, and such critics as John Masfield or Sidney Lanier.

Proud of their professional brethren who have excelled as litterateurs, physicians will take delight in recommending the lives and works of men like Rabelais, Oliver Goldsmith, Keats, Thomas Browne, Robert Bridges, Oliver Wendell Holmes, Weir Mitchell, and many others. Nor must we forget to suggest the writings of our present colleagues, such as "What

Men Live By," by Richard Cabot, "Medical Leaders" by Lambert and Goodwin, "Fear," and "Foursquare" by Oliver, "American Medical Botanists" by Howard A. Kelly, "Old Age" by Warthin, various books by Joseph C. Collins, poems by W. S. Thayer, and by Merrill Moore, and the many biographies of physicians by physicians, such as "John McCrae" by Sir Andrew Macphail, "The Life of Sir William Osler" by Harvey Cushing, and "The Life of Sir Clifford Allbutt" by Sir Humphry Davy Rolleston. "To Begin With" by the well known biologist Raymond Pearl may also be passed around with advantage.

The mind, like the body, will thrive best on a mixed diet, and he who experiences the variety of a number of literary forms will derive from his reading a satisfaction free from the dangers of ennui. For even Homer nods, and the man with untold hours to spend in the company of books may well get too many of one kind. A

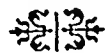
little careful precaution, however, will obviate this difficulty; if Emerson be followed by Melville and Melville by Poe, the likelihood is that none of them will pall.

Out of the legion of books, literary, scientific, and philosophic; out of novels, poems, and dramas; out of histories, biographies, travels, and memoirs; out of treatises, essays, and letters; out of all these and many more which admit of no categorical classification, every intelligent reader should be able to find two or three kinds which alternated with one another, will cause continuous felicity.

In the second oldest book in the world, written 2550 B.C. we read, "Live, therefore in the house of kindness, and men shall come and give gifts of themselves."

This address I joyfully dedicate to the many friends and patients who in return for my literary ministrations have showered me with wonderful books.

"The good life is one inspired by love and guided by knowledge."—Bertrand Russell.



## BOOK REVIEWS

CANCER. By Willy Meyer, M.D. N. Y., Paul B. Hoeber, Inc., 1931.

Whether one agrees or not with the writer of a book does not make that book any the less interesting or detract one whit from its value. Many there are who will take issue with Dr. Meyer concerning his thesis. But when a man with a scientific background, a keen analytical mind, and nearly fifty years' experience which have been crammed with actual clinical work writes a book, one will do well to read carefully what he has to say.

Willy Meyer, a student of a school that passed away with the Victorian age, a former pupil of the celebrated Trendelenburg, one of the busiest surgeons of his day in New York, known from coast to coast and in Europe, especially for his researches in the cancer problem, has written a scientific and interesting and human document.

The book is in two parts. Part 1 deals with The Origin, The Development and The Self-

Perpetuation of Cancer. In this part the author details the general aspects of the cancer problem, changes in cancer developing in single cells, the dead cell and focal necrosis effects, and changes in cancer developing in the system as a whole. The part ends with a synopsis and a diagram of the preceding chapters. Part 2 deals with The Therapy of Cancer. The general aspects of the therapy of cancer are considered, as are the remedial effects in cancer of fever, of acidosis, a summary and a retrospect and an outlook. There is an index of personal names; also, an index of subjects.

The book has 427 pages, illustrated, and typographically it is a work of art. Every student of the cancer problem should have this work on his shelves.

ABDOMINO-PELVIC DIAGNOSIS IN WOMEN. By Arthur John Walscheid, M.D. St. Louis, C. V. Mosby Co., 1931.

This is an excellent work. Any man who

specializes in gynecology or treats the diseases peculiar to women and also engages in general practice will profit by reading this book. It covers, in detail, and from many angles not met with in the usual book on the subject, the matter of diagnosis. Excessive use of microscopic techniques and sections has been avoided.

The book is divided into a general and a special section. The former deals with general causal factors, pathologic processes, symptoms, and diagnosis, while the latter considers the separate organs from the standpoint of diagnosis.

**HIGH FREQUENCY PRACTICE for Practitioners and Students.** By Burton Baker Grover, M.D. Ed. 6. With Appendix. 651 pp. Illus. with engravings. Thoroughly revised and rewritten. Kansas City, The Electron Press, 1931.

That this is the sixth edition would indicate that there has been a demand for this book. In spite of this, the typography and general makeup leave much to be desired. The subject is covered with a certain degree of thoroughness and the addition of portraits of the men who have contributed to the advancement of physiological therapeutics is admirable. However, the book suffers from the overenthusiasm of the author for physical therapy. He accepts as absolute facts matters which may still be considered in the realm of theory. This, unfortunately, is a fault of many of the newer books on this subject.

**HISTORY OF THE ORLEANS MEDICAL SOCIETY 1878-1928.** By A. E. Fossier, A.B., M.A., M.D. 243 pp., illus., 1930.

This is an interesting and concise history of the Orleans Parish Medical Society with portraits of its prominent members both past and present. This type of book is very desirable and should be further encouraged in this country. The story of the development of one of the largest medical libraries in the country by a local medical society makes very interesting reading. It is to be hoped that publications of this kind will induce other

societies to produce similar volumes so that a current record may be had of the medical history of the United States in the making.

**TEXT-BOOK FOR NURSES.** By E. W. Hey Groves, M.D., B.Sc., M.S., F.R.C.S., and J. M. Fortescue-Brickdale, M.A., M.D. (Oxon.), M.R.C.P. (Lond.). The Medical Section revised by J. A. Nixon, C.M.G., M.D. (Cantab.), F.R.C.P. (Lond.). Ed. 4, 665 pp., 229 illus., N. Y., Oxford Univ. 1930.

This is a splendid textbook on anatomy, physiology, surgery and medicine for nurses. The English point of view may make it perhaps impractical as a teaching book in this country but as a reference book for those who instruct nurses we know of none better and many physicians will be glad to have it in their library for reference. Like all Oxford publications, this is a model of good book-making.

**OBSTETRICS.** By J. Whitridge Williams. Ed. 5, 1088 pp., 17 plates, 690 illus., N. Y., D. Appleton & Co., 1927.

The fifth edition of a famous book. This edition has been entirely revised, reset, and brought thoroughly up-to-date. As in the previous editions, this book is particularly strong in pathology which has been so sadly neglected in so many American books on obstetrics.

**MEDICAL & SURGICAL YEAR-BOOK.** Physicians Hospital of Plattsburgh, Comprising Wednesday Afternoon Invitation Lectures, Papers of the Cardiac Round Table, The First Beaumont Lecture, Collected Papers by the Staff. 322 pp., illus., Plattsburgh, N. Y., The William H. Miner Foundation, 1930.

This volume includes the papers indicated in the title and is a great step forward over the average hospital year-book. This book is of historical interest as coming from the town where Beaumont made his famous experiments in the physiology of digestion and is an indication that the spirit of Beaumont still prevails there.



# PRINCIPLES OF PREOPERATIVE & POSTOPERATIVE TREATMENT

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# PRINCIPLES OF PREOPERATIVE & POSTOPERATIVE TREATMENT

## CHAPTER VI

### WATER BALANCE, DEHYDRATION, AND THE PREOPERATIVE AND POSTOPERATIVE ADMINISTRATION OF FLUIDS

#### I. THE IMPORTANCE OF WATER METABOLISM

The general importance of water in metabolism is ordinarily too little appreciated. The water supply of the average individual in health characteristically presents no problem, for not only are conditions of modern living such that water and water-containing foods are abundantly available for human consumption, but the normal body easily compensates for minor variations in output and input so completely that negligence in making the fluid needs of the body a matter of conscious concern ordinarily works little or no hardship on the metabolic processes.

Under the unusual circumstances of hospitalization, however, this state of affairs no longer obtains. Not only is the patient who comes to the hospital the subject of a greater or less degree of metabolic imbalance, but at least, when confined to his bed, he is dependent to a greater or less degree upon attendants for the supplying of all his physical needs. In the case of semiconscious and unconscious patients this dependence becomes extreme or absolute.

The absolute control of a patient's water supply is, indeed, a serious responsibility, for although food starvation results seriously or fatally only when prolonged for considerable periods of time, absolute water privation speedily results disastrously and causes death within a relatively short period of time. Whereas food starvation is tolerated by healthy human

beings for intervals as long as two months, complete curtailment of water causes dissolution within a relatively few hours. Rowntree<sup>1</sup> mentions an Italian political prisoner, Viterbi who, voluntarily refraining from food and drink, died only after eighteen days, but estimations based upon the period of survival of individuals lost in the desert seem to indicate that thirty-six to seventy-two hours is the usual time limit of life for persons completely deprived of water.

On the basis of animal experimentation it has been estimated that the total water content of the body tissues amounts to about 70 per cent of the body weight; an animal may lose as a result of starvation nearly all of its glycogen and fat and about half of its protein and still live; during this process its body weight may be diminished over 40 per cent. The loss of 10 per cent of the water content of the body, however, leads to serious disorders, and death is said to ensue when 20 to 22 per cent of the water content is lost.

The danger of over-supplying individuals with fluids by mouth is ordinarily not great. Excess fluid intake usually results simply in excess fluid output. The amount of fluid capable of absorption by the alimentary tract during the course of twenty-four hours is not usually appreciated. It has been estimated that the total amount of water excreted into the intestinal canal as saliva, gastric juice, bile, pancreatic juice, and succus entericus, amounts to from 7,500 to 10,000 c.c. per day, and this amount is, of course, reabsorbed virtually in its entirety. The 2 to 3 l. of fluid ordinarily added to this burden through intake of fluid by mouth constitute, therefore, but a small fraction of the total normal absorptive load of the digestive tract.

The fluid requirements of the human body in health have not been adequately determined. They vary considerably with different individuals under similar conditions, with the same individual under different conditions, and with the general status of the bodily processes at all times. The effect of specific diseases and disease syndromes on the fluid requirements is even less well understood.

As frequently practiced, the determination of the amount of fluid to be supplied to a person who is sick becomes very largely a matter of personal opinion. Of two equally competent surgeons one will judge a certain amount of fluid to be adequate in any given case, whereas the other will judge double this amount to be inadequate. Accordingly, it is easy to find competent authority to establish the adequacy of relatively small amounts of fluid, 1000 to 1500 c.c. per diem, under conditions of early postoperative convalescence, whereas equally competent authority can be cited to establish the inadequacy of 3000 c.c. or 4000 c.c. The rationale of "forcing" water postoperatively, i.e., of supplying several liters in the course of twenty-four hours, has been emphasized during recent years in an attempt to overcome a natural therapeutic lethargy formerly exhibited by surgeons, in accordance with which many patients were allowed to become partly or even seriously dehydrated. Still more recently the pendulum of opinion has started to swing in the opposite direction and it has become somewhat of a vogue to emphasize the dangers of overtreatment, and to dwell upon the importance of postoperative rest undisturbed by mechanical devices, such as must frequently be invoked for the administration of the larger amounts of water considered desirable under the "forcing" regime.

The entire question of how much fluid to give the sick patient is one in connection with which generalizations are apt to be of little value. One patient will require more fluid, another less, in accordance with a variety of circumstances, internal and external, organic and functional. The only unfailing way in which to rationalize the matter for a given surgical patient is to invoke the concept of water balance, in much the same manner as the internist invokes the same principle when confronted with a case of anasarca.

## II. WATER BALANCE

Water balance may be defined as the ratio between the total intake of water by ingestion of both fluids and solids, or

semi-solid foods, and the excretion of water by the emunctories, kidneys, lungs, skin, and bowel.

Celsus,<sup>2</sup> in 1837, was probably the first author to mention the importance of the determination of the water balance. In connection with a discussion of dropsy he said "nor is it improper to measure both the drink and the urine, for if more fluid is excreted than is taken so at length there is hope of good health."

Under conditions of health, as well as in chronic disease, the accurate determination of water balance is always a matter of some difficulty. Fluid intake is not only dependent upon the amount of fluid received as such, but its computation involves also a consideration of the amount of water introduced with solid and semi-solid foods, as well as the amount of water formed chemically during the various processes of food metabolism. In estimating the fluid intake a fairly accurate estimation of the water content of foodstuffs may be derived from tables of food analysis,<sup>3</sup> but in cases in which a considerable degree of accuracy is desired samples of the various foods actually used must be analyzed. An idea of the amount of the water of oxidation can be obtained from representative calculations; thus Rowntree<sup>1</sup> finds that the oxidation of 100 gm. of protein characteristically yields 41 gm. of water, 100 gm. of starch yields 55 gm. of water, and 100 gm. of fat about 118 gm. of water.

The computation of fluid output is also somewhat complicated since water is eliminated not only by the kidneys but by the skin, by the alimentary tract, and by the lungs. By far the greatest part of the elimination of water by the body is, of course, by way of the kidneys, an amount varying directly with the amount of water ingested but an amount averaging from 1500 to 2000 c.c. per day; kidney elimination varies somewhat with the amount of water excreted by the lungs and skin, the more excreted by the latter channels, the less excreted by the kidneys and vice versa; accordingly, exercise and climate affect the ratio to a greater or less extent; the

average loss by both lungs and skin probably averages about 700 c.c. The amount of water excreted in the feces varies considerably with the diet; on a vegetarian diet it may amount to as much as 300 c.c. but ordinarily varies between 60 and 150 c.c. daily.

Fortunately, on the other hand, for the ease with which water balance may be determined in acute surgical cases many of the variables previously mentioned as applying to ordinary cases are eliminated by the nature of the conditions under which surgical patients find themselves. At the time when the problem of water balance is most acute the surgical patient takes little or no nourishment in the form of solid or semisolid food, so that virtually the entire intake is water and, accordingly, the amount of water supplied as such constitutes approximately the total fluid intake. At the same time, the excretion of water by avenues other than the kidney is usually at a minimum or at least is at a relatively low and constant level, so that for practical purposes the kidney output may be taken as representing the total water excretion.

The simple expedient, therefore, of measuring a patient's total fluid intake and total urinary output per unit interval of time places at the surgeon's disposal a tolerably exact method for estimating whether a given surgical patient's water balance is in a state of stable or unstable equilibrium. The importance of this device can scarcely be overemphasized. The manner in which it operates is quite simple.

As previously stated, from 1500 to 2000 c.c. of urine may be taken as the usual output of the kidneys during the course of twenty-four hours in health. It is doubtful whether such an amount is altogether sufficient in disease, but, at all events, amounts less than this may probably be considered to represent a condition of oliguria. In this connection the work of Heitz-Boyer on the concentrating power of the kidney is interesting. He has shown that in disease the power of the kidney to concentrate is markedly decreased, so that double or treble the normal amount of water must be secreted in

order that a normal amount of excretory waste material may be eliminated.

Many of the patients subjected to surgical manipulations, in the natural course of events, already are subjects of impaired kidney function of a degree susceptible of clinical demonstration. However, minor impairments become manifest only under the unusual conditions of stress and strain incident upon surgical manipulations. That inhalation anesthesia alone is capable of bringing to light previously unrecognized renal degenerative changes is suggested by the experimental work of MacNider.<sup>4</sup> He found that although little disturbance in urinary excretion or acid-base balance of the blood occurred in young animals during prolonged general anesthesia, urinary output was readily reduced in older animals, and a condition of acidosis developed fairly promptly.

These and other considerations suggest the importance of maintaining a urinary output of not less than 1500 c.c., and it may therefore be taken as a cardinal principle that fluid intake should ordinarily be ample to ensure this state of affairs.

In the presence, however, of discrepancies between the urinary output and the fluid intake lies the greatest value of the water balance determination. Discrepancies may arise in at least four different ways: (1) the kidneys may fail to excrete normally, so that there arises a retention of fluids within the tissues; (2) excessive amounts of fluid which have undergone normal absorption may, on the one hand, be vomited or may, on the other, be passed by bowel as a result of the development of diarrhea; (3) fluids may fail to be absorbed even though properly administered; and (4) unrecognized lapses in technique may give rise to undetected mechanical losses. Only in the use of a systematic method of determining water balance may these abnormalities be brought to light in a satisfactory proportion of cases.

It is a wise precaution, therefore, to order in all early postoperative cases, at least, a separate charting of all fluids given such patients and of all urine passed. These chartings

should be kept on a separate sheet of paper and should be totalled at least once in every twenty-four hours so that the medical attendant may be readily apprised at a glance of the particular state of affairs in connection with each patient.

If the twenty-four hour total of urinary excretion falls below a predetermined minimal figure more fluid must naturally be supplied, provided of course, that no considerable discrepancy exists between input and output, and when such a discrepancy is found to exist, immediate steps must be taken to discover whether it is due to retention of fluid, to improper absorption, to diarrhea or vomiting, or to faulty technique in administration of fluid.

### III. DEHYDRATION

Dehydration should never be allowed to develop in surgical patients to a point at which it becomes clinically recognizable. The earliest changes in the direction of dehydration consist in minor degrees of blood concentration accompanied by a diminished and relatively concentrated urinary output. The blood concentration can be measured roughly by means of hemoglobin determinations, by blood counts, or by hematocrit readings; the urinary concentration is manifested in a high specific gravity which assumes a rather constant level. The physical signs consist of dryness of the skin, parching and cracking of the tongue and general dryness of the oral cavity, and in severer degrees, of enophthalmus, fever, restlessness and delirium. Dehydration kills patients by interfering with the migration of the erythrocytes through the smaller capillaries of the parenchymatous organs, and thus preventing tissue respiration; the tissues die as a result of slow and progressive asphyxia. Dehydration is characteristically accompanied by the development of acidosis, because both respiration and excretion are disturbed; carbon dioxide fails to be excreted in normal amounts from the lungs, and fixed acids, principally in the form of the acid phosphates, are incompletely excreted by the kidneys.



## IV. METHODS OF FLUID ADMINISTRATION

A. ADMINISTRATION PER OS: Naturally the physiological method of administration of fluids, i.e., *per os*, is best, when applicable, and should therefore be used when not contraindicated. In cases in which the gastrointestinal tract has not been the seat of operative attack and in which a general inhalation anesthetic has not been employed, it may be quite feasible to give patients either immediately, or at least very soon after operations, almost unlimited supplies of water by mouth.

Patients operated upon for goiter under local anesthesia, for instance, may in most cases tolerate water by mouth immediately after they are returned to bed or even while still on the operating table. Since these patients need large quantities of water to take care of their excess metabolic requirements, and since excess metabolism involves the liberation of abnormal quantities of heat which in turn requires dissipation, such patients may conveniently be encouraged to drink unrestrictedly of *ice water*.

Certain other patients, those who have undergone amputations under local anesthesia, the removal of hemorrhoids under sacral anesthesia, and many or most of the operations of minor surgery may tolerate either hot or cold water by mouth very well.

A practical point in connection with patients who receive quantities of either hot or cold water by mouth, should, however, be mentioned in passing; it has to do with the taking of temperatures. Rather obviously the local heating or cooling effect of water taken by mouth renders *per os* temperatures thoroughly unreliable; nurses and attendants should be carefully instructed to take either by axilla, or better still by rectum, the temperatures of patients having free access to hot or cold water by mouth.

Water when taken into the body in quantity in the natural manner by mouth is absorbed mainly by the small intestine.

The stomach is capable of absorbing some water, but ordinarily the amount so absorbed is negligible; for this reason stenosis of the pylorus and dilatation of the stomach are accompanied by tissue thirst which cannot be relieved by burdening the stomach with more water. In the small intestine, however, the absorption of water is rapid and ordinarily virtually complete, since the contents of the large bowel are characteristically at least semisolid. Water is presumably absorbed by the villi of the small intestine, since the ingestion of quantities of water experimentally does not increase the flow of lymph from the thoracic duct but does dilute the blood in the portal vein. Water absorption takes place partly in accordance with the principles of osmosis and diffusion, but the process is actually much more complicated than this, since it can readily be shown that under certain circumstances, at least, the cells covering the villi are capable of exerting a selective action for water in accordance with which they absorb it against all known laws of physical chemistry.

Unless relatively large quantities of water are imbibed, virtually all of it is absorbed from the small intestine, and the feces are passed in a dehydrated state, as previously mentioned. Unduly large quantities of water, however, are incapable of complete absorption, and may lead to nausea and vomiting, irritations of the gastric and duodenal mucosa, diarrhea, and rarely even to hydremic plethora. Such results may occasionally ensue when as little as 4 to 5 liters of water in addition to the fluid normally taken with the food is imbibed in the course of twenty-four hours.

Under normal circumstances all water absorbed by the small intestine in excess of the amount required for cellular metabolism is rather promptly excreted by the various water excretories.

B. PROCTOCLYSIS: Surgical patients for one reason or another are frequently unable to take, or at least to retain, fluids by mouth. For such cases proctoclysis is frequently the method of choice.

Proctoclysis consists in the administration of fluids by rectum; the fluid may be plain water or may contain certain absorbable dissolved substances of nutritive or medicinal value.

There are two general methods of introducing fluids for purposes of proctoclysis: (1) the injection of a considerable quantity of solution at relatively infrequent intervals, the so-called "retention enema" method, and (2) the injection of small amounts of solution drop by drop at much more frequent intervals and over a more considerable period of time, the "rectal drip" method.

The retention enema is relatively seldom used for purposes of proctoclysis; when any considerable amount of fluid is introduced at one time into the rectum it tends to excite peristalsis and to be expelled, i.e., to act as a cleansing rather than as an absorptive solution. Amounts in excess of 4 oz. will often act thus, and amounts in excess of 8 oz. are not often used postoperatively in abdominal cases even for cleansing purposes because of the uncomfortable sensations they produce and the danger of exciting over-violent intestinal contractions. If retention enemata are employed, therefore, they should be small, and the temperature at which they are injected should ordinarily be essentially that of the rectum or even somewhat higher (110° F.).

The "continuous drip" proctoclysis, first introduced by John B. Murphy<sup>5</sup> and accordingly often called the "Murphy drip" proctoclysis, is, except in rare cases, the method of choice and consists in allowing fluid to pass drop by drop into the rectum through a tube which is left in the rectum during the entire course of the procedure. Four or five liters of fluid in the course of twenty-four hours may sometimes be given in this way to a patient of average weight with a minimum of discomfort and a maximum of therapeutic effect.

The apparatus used for this purpose consists of three essential parts: (1) the reservoir, or container, from which the fluid is allowed to flow, (2) the connecting tube which con-

ducts the fluid from the first to the remaining part of the apparatus and in which is interpolated a glass dropping tube and an adjustable clamp by means of which the rate of delivery of the solution may be varied at will, and (3) the rectal tube which projects into the rectum.

The container may be of any suitable shape and size, but usually the size should be such as to provide a cubic capacity of not less than 1000 c.c. The fluid to be placed in the container is warmed to 120° F. in order to allow for a certain inevitable loss of heat during its passage through the rest of the apparatus and a delivery of solution into the rectum at a temperature as near 110° F. as possible (Fig. 27).

Various containers of special design, the more elaborate of which make use of the principle of the commercial vacuum bottle, or "Dewar bulb," have been designed to maintain the temperature of the solution in the container at the proper level, but such are not necessary; the more simple the apparatus the less time and energy are consumed in preparing it and the more frequently will it be employed. An ordinary enema, douche, or irrigating can makes a suitable container, and the temperature of the solution may be maintained either by surrounding the can with hot water bottles or by allowing a 16 candle power electric incandescent light bulb to dip into it. Of course, the temperature at which the solution is delivered into the rectum, rather than the temperature within the container, is the important factor, and the former may conveniently be regulated, as Selinger has suggested,<sup>6</sup> by allowing the connecting tube to pass between two hot water bottles placed in the patient's bed, care being taken if this expedient be used, however, to protect the patient from coming into contact with the hot water bottles and accidentally becoming burned thereby; naturally, this applies with especial force in the case of the unconscious patient.

The tube for insertion into the rectum may be of either the hard or soft rubber variety; if the former, it may either be curved or straight, and in any case it may be conveniently of

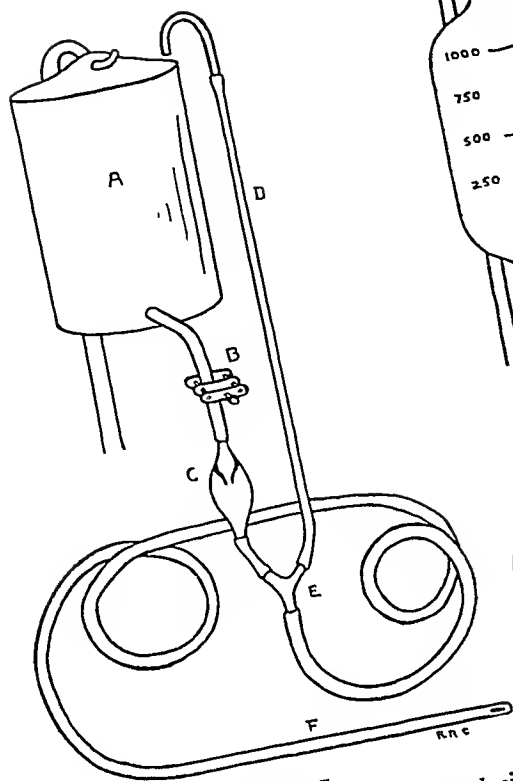


FIG. 27.

FIG. 27. An ordinary simple proctoclysis apparatus. A is an enema or douche can of white enamel. B is a screw clamp placed about a short piece of rubber tubing leading from outlet of can; this screw clamp adjusts rate of flow of solution to C which is a glass "dropping tube"; by observing this part of the apparatus the rate of delivery of the solution can be determined by counting number of drops per minute. E is a glass T tube which connects below with a length of rubber tubing and rectal tube F; above it is connected with a rubber return tube D which terminates in hook made of bent glass tubing. This latter part of the apparatus functions only in case pressure within rectum of patient increases to point at which solution is regurgitated; if this happens the solution is forced back into enema can rather than into bed and onto floor; in operation hook is allowed to hang over edge of can.

FIG. 28. An ordinary simple type of hypodermoclysis apparatus. A and A' illustrate two different types of reservoir; they are both made of glass. A is a bottle with an outlet blown in the bottom. A' is an ordinary Erlenmeyer flask which is provided with a rubber stopper and two bent glass outlet tubes, the long tube equalizes pressure and the short tube is the outlet tube to the remainder of the apparatus. The flask is filled, stoppered, wrapped in linen and sterilized; when put into use it is inverted and either hung from a hook as illustrated or passed through a supporting ring-stand. When using apparatus of bottle type bottle is dry-sterilized and must be filled with sterile solution after remainder of apparatus has been made ready for use. B is a screw clamp, C a glass dropping tube, D a glass T tube, and E and E' are the needles in one bundle except for needles; to prevent rusting, the latter, if of steel, are usually sterilized separately just before use.

size 32 F. The tube is inserted for 2 in. into the rectum and is fastened in place so that it may neither progress nor recede by means of adhesive strips fastened to the inner aspect of the patient's thigh.

Kanavel and Koch<sup>7</sup> have suggested a useful adjunct to the apparatus previously described, consisting of a return tube interpolated between the conducting tube and the enema can, which allows for expulsion of flatus and also permits of a reflux of fluid into the main container if pressure within the rectum becomes great.

The apparatus having been prepared, the container is hung on some convenient hook either on the patient's bed or alongside of the latter at a height such that the distance between the fluid level in the container and the rectum of the patient is between 18 and 24 in. The adjustable clamp is loosened until from 30 to 40 drops are delivered to the rectal tube per minute as shown by the dropping tube, and the operation of the apparatus then progresses automatically until the entire amount of the solution has been delivered.

As originally devised by Murphy,<sup>5</sup> the solution for the rectal drip consisted of normal saline solution, but a solution of sodium chloride has little to recommend it in the average postoperative case, and such a solution does present certain fairly obvious disadvantages: (1) the postoperative patient usually has no chloride deficiency, and the administration of an excess of chlorides simply throws an added burden on the kidneys and this at a time when the latter are already overworked, the net result often being the development of an edema of the eyelids and ankles and possibly even of the lungs; (2) postoperative thirst, especially after ether anesthesia, is severe enough if it be not increased by the addition of a chloride thirst component; (3) postoperative nausea and vomiting are increased in precisely the same manner and by the same mechanism by rectal saline solution as when salt solution is taken into the stomach. Ordinary tap-water meets the primary requisite in some cases and is absorbed readily.

As much as 5000 c.c. of water may be given to a patient in the course of twenty-four hours by rectum by means of the drip as previously stated, but usually such an amount is excessive, and, furthermore, it is highly desirable to alternate rest periods with periods of proctoclysis in order that the rectum be not unduly irritated by a too long continuation of a condition to which it is not normally accustomed. It is therefore ordinarily advisable to allow an hour's rest between succeeding proctoclyses of 1000 c.c.; 3000 c.c. of fluid may be administered within twenty-four hours without producing undue irritation when this precaution is taken, and the procedure may be continued for as long a period of time as may be necessary. In the average postoperative case no more than one proctoclysis of 1000 c.c. may be necessary.

The promiscuous addition of various ingredients to proctoclyses is to be avoided, but there are a few substances which may be added, when indicated, to very good advantage. The most important of these is dextrose; the place of this substance in the biochemical economy has been discussed at some length in another connection. Dextrose, in amounts varying from 2 to 10 per cent, can be added with benefit to most proctoclyses, the commercial dextrose, and not the more expensive chemically pure substance, being used for the purpose. It is often said that the stronger solutions of dextrose are irritating to the rectum and cause a proctitis; this is undoubtedly true if the administration be continued over too long a period of time, but the same holds true even for much weaker solutions and even for the simpler proctoclyses of normal saline solution and tap water. The irritation in these cases is due not so much to the character or strength of solution used as to the mere prolongation of an unphysiological condition, the normal contents of the rectum, sigmoid and most of the colon being not liquid but semi-solid.

The addition of sodium bicarbonate to proctoclyses is sometimes desirable and sometimes undesirable; occasionally it may have some value in combating an acidosis, as considered



in another connection; usually, however, it is indifferent with respect to its effect after absorption, occasionally, as in alkalosis, it may be positively harmful. Though usually indifferent as far as its effects after absorption are concerned, it usually is of some local value, because of its alkalinity, in liquefying and removing the characteristic slimy film of mucus from the bowel, thereby facilitating absorption. For this reason it is often, if not usually, desirable to use about 2 per cent of sodium bicarbonate in solutions to be used for proctoclysis.

The addition of tincture of digitalis to proctoclyses has been advocated by many clinicians during the past ten years, partly on the basis of its supposed beneficial effect on the cardiac musculature after absorption, and partly because of its supposed beneficial effect upon the intestinal musculature in the prevention of distention or meteorism. The question of the effect of digitalis on the relatively normal cardiac musculature has already been discussed, and the conclusions given hold true regardless of the manner of administration, whether per os or per rectum. Furthermore, there is apparently no proof that digitalis has any value whatsoever as an antimeteoritic: Selinger states that in a moderately large series of cases<sup>6</sup> he has not been able to note any particular effect of value in this respect; indeed, he mentions two especially severe cases of distention developing in cases so treated.

Not a few clinicians have expressed their dissatisfaction with proctoclysis as a method, contending that a considerable number of patients do not tolerate the use of the method well and expressing the view that the more drastic methods of hyperdermoclysis and intravenous infusion are preferable in many or most cases.

The experimental evidence on this point is unconvincing: thus, for instance, Levi<sup>8</sup> on the basis of experimental data questions the efficacy of glucose solutions when given per rectum. His pessimistic attitude is based on observations upon (a) 16 normal fasting men, (b) 8 fasting diabetics, and (c)

10 postoperative patients. Retention enemata of 500 c.c. of glucose solution were given, and the blood sugar was estimated for the most part at half-hourly intervals for two and one-half hours. The percentage strength of the glucose solution, however, was 10 per cent in the normal fasting individuals, 16 per cent in the diabetics, and though not stated, probably correspondingly high in the postoperative cases. The blood sugar rose somewhat in 11 of the 16 normal individuals, but fell in the other 5. In 5 of the 8 diabetics the blood sugar concentration increased, whereas in the other 3 it decreased. In all the postoperative cases there was a consistent rise. From these data Levi concludes that the rectum and colon vary in their power of absorbing glucose in different subjects and that the administration of glucose by rectum would appear to be of little value as a means of maintaining bodily nutrition.

Obviously such conclusions are quite gratuitous since they are based on three entirely unwarranted assumptions: (1) that the retention enema is the only, or at least the most efficacious, method of supplying glucose rectally, (2) that the strength of solution is a matter of indifference or at least that a concentrated solution is of optimum efficiency, and (3) that the blood sugar concentration is a measure of the absorption of dextrose, or at least that absorption of glucose from the rectum will necessarily raise the blood sugar concentration.

Varela and Rubin<sup>9</sup> injected large amounts of 40 per cent dextrose solution into the rectal ampullas of patients and concluded from examinations of sugar concentration in the peripheral blood and tests for urinary sugar that minute quantities of dextrose were absorbed during the period of retention of the enema; the colon soon became irritable, however, and expelled the solution. Such observations are, of course, of little clinical value because of the unduly high percentage strength of the enemata and also because of the method by which they were given, retention enemas having been clinically well-nigh completely supplanted by the "rectal drip."

Reach<sup>10</sup> and Franke and Wagner<sup>11</sup> using similar methods, viz., concentrated solutions and retention enemata, found little evidence of absorption; the former, using the respiratory quotient as a measure of absorption, concluded that slow and slight absorption occurred; the latter observed only very slight increases in the peripheral blood sugar level.

Hari and Halasz<sup>12</sup> obtained slight changes in the respiratory quotient when dextrose solutions were introduced into the rectums of dogs in which a ligature had previously been tied tightly about the ileocecal valve.

Tallerman<sup>13</sup> injected 180 c.c. of 33 per cent dextrose solution into the rectums of human subjects and was able to demonstrate a slight and slow increase in the peripheral blood sugar level.

McNealy and Willems,<sup>14</sup> using 18 dogs which had been deprived of food for sixteen to eighteen hours and introducing 5 per cent solutions of dextrose into isolated loops of colon and ileum through laparotomy incisions, found that no appreciable absorption occurred from the colon but that considerable absorption occurred from the ileum. They concluded from these observations that dextrose administered by rectum is absorbed only when regurgitated into the ileum through an incompetent ileocecal valve.

It is generally conceded, of course,<sup>14</sup> that sodium chloride solution and water are absorbed rapidly by both colon and ileum.

Many or most of the unfavorable opinions expressed with respect to proctoclysis in general probably result from observations based upon inconstant or even irrational techniques of administration. It is undoubtedly true that a certain number of patients, for one reason or another, will not tolerate the use of proctoclysis, and that among those who do tolerate the method some will absorb more rapidly and some more slowly. Like all methods used in medicine a certain amount of intelligence must supplement the mere mechanical part of the performance of proctoclysis; attention to details is of impor-

tance if the method is to succeed. The four principal details to be considered are (1) the temperature of the solution as it is delivered into the rectum, (2) the height of the column of water above the level of the rectum, which in turn, of course, controls the pressure with which the solution is delivered, (3) the tolerated rate of flow, which must be determined to a greater or less extent separately for each case, and (4) the length of tubing allowed to project into the rectum. Careful attention to these matters and rigid adherence to the principles enunciated in connection with them will unquestionably make the method of proctoelysis one of the most valuable postoperative methods of treatment in the surgeon's entire armamentarium, and the number of patients in whom the method cannot be used successfully will invariably be found to vary inversely with the care and intelligence used in the employment of the method.

C. **HYPODERMOCLYSIS:** Hypodermoclysis consists in the injection of fluids under the skin by means of a hypodermic needle for purposes primarily of maintaining the fluid requirements of the body. Whereas, however, plain tap water or even distilled water may be used as a fluid for proctoclysis, water itself is unsuitable for purposes of hypodermoclysis because when using the latter method injections are made into the tissues themselves, and the principles of osmosis and diffusion must be respected. Fluids for use in the administration of hypodermoclysis should be prepared in such a manner as to ensure virtual isotonicity with the tissue cells. Only two substances are very frequently used in hypodermoclysis to provide isotonicity, (1) sodium chloride and (2) dextrose.

Sodium chloride solutions are open to the same general objections when used hypodermically as when used in proctoclyses, objections which need not be here repeated; in hypodermoclysis, however, the solution is forced into the tissues, and the tissues, not being able to reject any of it, must deal with its constituent parts as best they may. If, then, in connection with hypodermoclysis sodium chloride be unwisely

forced upon the body or forced upon the body in unduly large amounts, the tissues being unable to express their resentment in the form of rejection or expulsion of the substance, morbid responses may be expected to ensue promptly and inevitably. For this reason the use of sodium chloride in the manner under discussion should not be undertaken without particular consideration of its possibilities for harm, especially in patients who exhibit any tendency toward chloride retention.

Dextrose, on the other hand, is open to few objections. It is a normal constituent of the blood stream and of most or all of the fixed tissues of the body. It serves as a readily available source of energy, and, being completely metabolized, makes no demands upon the excretory function of the kidney. Even in diabetics its use is not contraindicated, for the metabolic energy of the surgical diabetic patient must be maintained at all costs, and the discovery of insulin has made possible and safe for the diabetic the metabolism of as much dextrose as may be deemed necessary.

In efficiency hypodermoclysis may probably be regarded as standing midway between proctoclysis and intravenous infusion. It is a somewhat more certain method than proctoclysis in that the variable factor of mucous membrane absorption is obviated. The fact, however, that fluid is delivered directly into the subcutaneous tissues does not at all mean that it then inevitably becomes absorbed into the general circulation. When the general circulation is sluggish or when the local circulation in the area selected for hypodermoclysis is inadequate either because of temporary abnormalities or the inherent anatomical arrangement of the tissues in the region, fluids administered by hypodermic needle tend simply to accumulate locally by a gradual distention of the tissue spaces.

Such passive accumulations of fluid in the tissues not only serve no useful therapeutic function, but become sources of actual danger in that they may themselves interfere with the local circulation to such an extent as to produce sloughs of the overlying skin as well as of the tissues primarily permeated by the fluid.

Hypodermoclysis is ordinarily a painful or at least a highly uncomfortable method of fluid administration from the point of view of the conscious patient; by carefully and rationally selecting the area to be used for hypodermoclysis this objection may be overcome to a certain extent, and by making use of a small amount of novocaine in the solution used, a method recommended by Bartlett,<sup>15</sup>—actual pain can largely be eliminated. However, even though actual pain be entirely obviated, the procedure cannot be rendered really comfortable, and the use of novocaine for this purpose is certainly open to criticism.

The injection of quantities of fluid into certain locations, especially under the breasts, is highly undesirable both from the point of view of the patient's comfort and because of the danger of producing local tissue sloughs. As is well known fatty tissues characteristically are provided with a relatively poor blood supply; when the blood supply is disturbed infection tends to occur and extensive slough may even result from mere pressure in the absence of infection. Care should be taken, therefore, to avoid the injection of solutions into tissues rich in fat. Muscular tissue is also unsuitable for the reception of quantities of solution; it is relatively dense, and fluids permeate it very slowly; furthermore, if sloughs should occur due to pressure effects the result would be disastrous. Easily distensible, loose, areolar connective tissue is preferred.

The sites of election for injection are (1) the axillae, and (2) the outer aspect of the thighs between the skin and the fascia lata; these sites provide considerable areas of easily distensible, loose areolar connective tissue, and the capability of absorption from these areas is ordinarily satisfactory. Half a liter of fluid can be accommodated without undue discomfort in either axilla or in either thigh.

To introduce fluid properly into the axilla the needle is entered at the lateral border of the pectoralis major muscle about 2 in. below the apex of the axillary fold of skin; the needle is directed upward, backward, and slightly medially

for about  $1\frac{1}{2}$  in. toward the apex of the axillary space, care being taken to avoid piercing the axillary vessels (Fig. 29).

To introduce fluid into the outer aspect of the thigh the

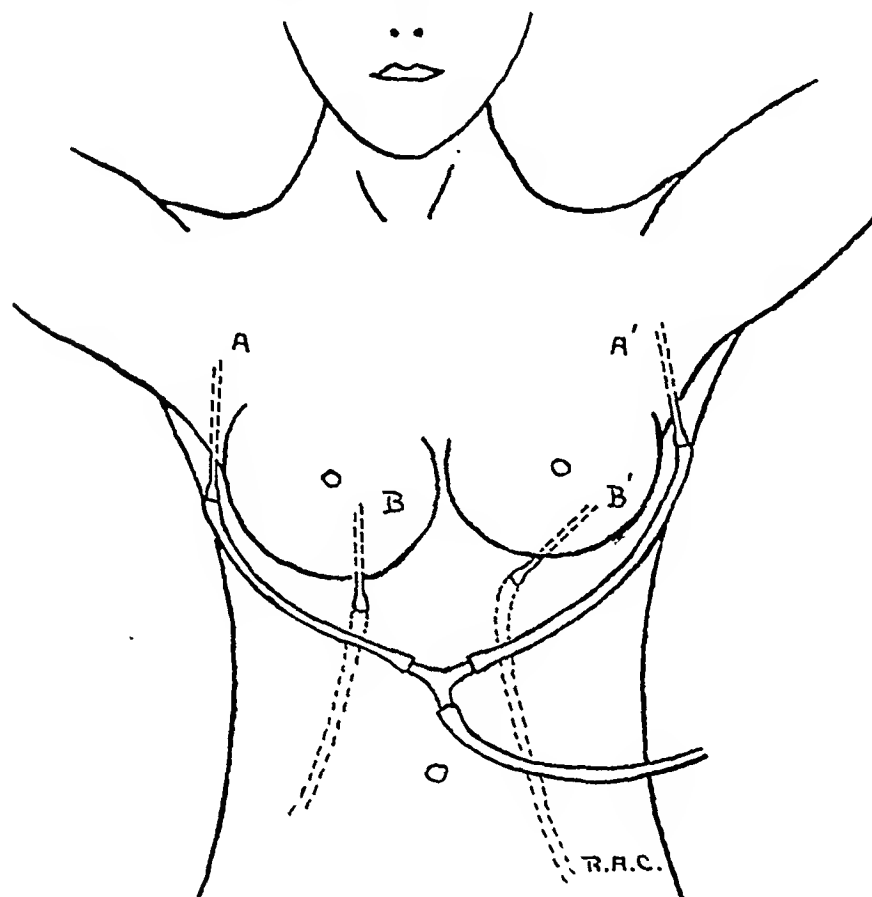


FIG. 29. Proper and improper methods of administering hypodermoclysis. Needles A and A' are in proper position; solution is delivered into loose areolar tissues of axillae, where it is not likely to produce sloughs and whence it is absorbed most satisfactorily. When injected under the breasts as at B and B' the solution is delivered into fatty tissue which has a relatively poor blood supply; in this case devitalization of tissue may occur with development of sloughs; in any case absorption is not active.

needle should be introduced at about the midpoint of the thigh on the lateral surface, the point being directed upward or downward, preferably the former, at a relatively acute angle with the skin, especially in thin patients, so as to avoid penetration of the fascia lata; the point of the needle should penetrate the tissues for a distance of an inch or slightly more (Fig. 30).

The institution of an infection either primarily during the introduction of the needle used in hypodermoclysis or subsequently during any necessary readjustments of the needle



FIG. 30. Proper method of administering hypodermoclysis in thighs. Iodine stains are shown on medial aspect of patient's left thigh; interne had been preparing to introduce needles improperly on inner aspect of thighs just before photograph was taken and hence the stain. Both needles, however, were introduced on the lateral aspects of the thighs, as shown.

should of course be scrupulously avoided. A wide area of the skin surrounding the proposed site of puncture should receive careful preliminary sterilization, the hypodermic needle should be handled aseptically during the puncture, should be fixed in position with a strip of adhesive plaster without contamination, and then should be covered with a piece of sterile linen or gauze to prevent subsequent contact with microorganisms.

The apparatus used for hypodermoclysis consists ordinarily of a glass container of at least 1000 c.c. capacity, a rubber connecting tube provided with an adjustable pinch-cock and





because of the possibility of infection, but mainly because the continuation of life itself depends upon the proper maintenance within the blood stream of certain osmotic, hydrogen ion, and other relationships, not all of which are certainly known or fully appreciated. The tolerance of the blood stream to the addition of fluids of widely different physico-chemical characteristics simply serves to illustrate the efficiency of the reserve capacity of this remarkable fluid tissue to deal with abnormal situations.

Two general varieties of intravenous infusion are practiced in accordance with indications, (1) massive infusion and (2) the intravenous drip infusion.

1. *Massive Infusion*: Massive infusion usually has for its primary object the restitution of depleted blood volume, and is invoked in cases of hemorrhage and shock whenever blood transfusion cannot be quickly performed. The nature of fluids used for purposes of infusion is such, however, that their action is generally transitory. No fluid has yet been devised which possesses enough of the physico-chemical characteristics of blood to be treated by the tissues in the same manner as the normal contents of the blood vessels. Osmosis, diffusion and diuresis rapidly rid the circulation of added water, and substances introduced as solutes are dealt with in various manners depending upon their respective characteristics but for the most part tend to be excreted in either an altered or unaltered condition by the kidney.

Smith and Mendel,<sup>16</sup> working with rabbits, found that when 0.9 per cent sodium chloride solutions were introduced rapidly (within two minutes) into the blood stream in amounts equal to the computed blood volume of the animal, more than 50 per cent of the solution thus added disappeared within five minutes, and the blood volume returned to normal within half an hour. Lamson, Abt, Oosthinsen, and Rosenthal<sup>17</sup> obtained similar results using dogs. Gasser and Erlanger<sup>18</sup> and Smith<sup>19</sup> have reported similar findings using solutions of dextrose.

## WATER BALANCE AND DEHYDRATION

Yesco, Passalacqua, and Judd<sup>17</sup> studied the effect of the intravenous infusion of 1000 c.c. of solution containing 10 per cent of dextrose and 1 per cent sodium chloride on the blood



FIG. 33. Massive intravenous infusion apparatus in operation. Patient's arm is fastened to an arm board, and presence of nurse would not be required except that this patient was delirious and required a certain amount of reassurance and restraint.

pressure, pulse rate, erythrocyte, and leucocyte count on 10 patients; the solution was given at body temperature and the

average rate of injection was 15 c.c. per minute. During the administration and sometimes for a variable length of time thereafter, usually not exceeding thirty minutes altogether, the systolic blood pressure and the pulse rate were found to increase and the diastolic blood pressure to decrease; within an hour, however, a complete readjustment of both blood pressure and pulse rate to the pre-injection level had occurred. This was taken to indicate that both glucose and sodium chloride when given by intravenous infusion do not remain within the blood stream longer than about sixty minutes. With respect to leucocytic changes there was found to occur a consistent decrease in the number of leucocytes immediately after the intravenous injection and either a return to normal or even a definite leucocytosis at the end of three hours. The erythrocytes similarly showed a definite decrease immediately following the injection and subsequent increase at the end of three hours, although they were characteristically less numerous at this time than at the time of the original injection. The authors conclude from these findings that infusion of dextrose and sodium chloride produces a leucocytosis at the end of three hours, but in criticism of this conclusion it may be urged that the discrepancy between leucocyte and erythrocyte counts can just as conveniently be explained on the basis of erythrocyte destruction, and this perhaps seems the more rational explanation because 10 per cent solutions of dextrose are hypertonic and capable of producing definite crenation, if not actual destruction of the red blood cells. Probably all the phenomena are capable of explanation on the basis of purely physical principles.

Only two classes of substances seem to subserve any valuable function apart from the very transitory increase in fluid volume produced by the administration of water, (1) certain inorganic salts, especially sodium chloride, and (2) dextrose. Attempts to increase the viscosity of infusion fluids by the addition of such substances as gum Arabic and thus increase the period of their sojourn within the vascular tree

have been generally disappointing in their results as mentioned in another connection. The tendency at the present time in surgery is to place little reliance on any fluid except blood when the indication is to provide increased vascular volume over a considerable period of time.

In an attempt to make ordinary solutions suitable for use in the emergencies of surgery, MacFee and Baldrige<sup>18</sup> have proposed massive infusions in the treatment of shock and shock-like conditions. These infusions consist of 2000 to 8000 c.c. of normal salt solution to which are added varying concentrations of dextrose at a single injection; the injection proceeds at the rate of 500 c.c. in ten to twenty minutes, about 4500 c.c. of solution being usually given. Infusions as large as these are probably not without danger.

It may be taken as a principle rarely found in error that although massive intravenous infusion may be depended upon to raise blood pressure once it never does so a second time.

2. *The Intravenous Drip (Matas)*: The method of prolonged intravenous medication by the administration of small amounts of solution directly into the circulation at so frequent intervals as to constitute a virtually continuous infusion was advocated by Matas many years ago<sup>19</sup> and has found a considerable field of usefulness subsequently. The method is, as Matas observed, particularly suitable for use in connection with "the great emergencies or crises of surgical practice." It is designed not to supplant, but to follow and supplement, primary massive intravenous infusions. It serves to prolong the effects of the primary infusion which, when given alone, produces, as previously stated, merely a transitory increase in the volume of the blood due to the rapidity with which ordinary artificial isotonic solutions are removed from the circulation by diuresis and osmosis.

The method is particularly applicable to those cases in which the other methods of supplying fluids are ineffectual, (a) enteroclysis, (b) proctoclysis, (c) hypodermoclysis. In the more serious types of surgical cases (a) enteroclysis may be

ineffectual because of paralysis or reversal of peristalsis, so that fluid even when introduced into the duodenum is returned forthwith to the stomach from which absorption is very slow indeed; (b) proctoelysis may be valueless because of an underlying stasis of the portal circulation or because of rectal intolerance, so that the fluid which is introduced either remains in the colon unabsorbed or is actually expelled therefrom; and (c) hypodermoclysis may be useless because of capillary stasis in the available areas, fluids when introduced into the tissues merely producing a condition of increased edema.

These conditions prevail notably in cases (a) of generalized peritonitis following rupture of gastric and duodenal ulcers, perforative appendicitis and gangrenous cholecystitis, and gunshot wounds of the abdomen, (b) in hepatic insufficiency with blockage of the common duct, (c) in advanced pyloric obstruction, especially in cases of malignancy with a complicating cachexia, and (d) after nephrectomy for pyonephrosis in cases in which there is an actual or threatened anuria.

*Technique:* The apparatus used for the institution of the continuous intravenous drip is essentially the same as that used in the performance of hypodermoclysis; instead, however, of terminating in a needle, the apparatus may conveniently be provided with a cannula which is tied into the vein after formal dissection of the latter. Whether a needle or cannula is used, the vein selected is usually one of those at the bend of the elbow, as illustrated in connection with the performance of blood transfusion and described in another connection, but some prefer the smaller veins of the wrist or back of the hand (Fig. 31); the arm is carefully but securely tied to an arm-board or fitted to a plaster splint; the skin over the area selected is sterilized, and the vein is punctured directly or is incised after careful dissection depending upon whether a needle or a cannula is to be used. When using a cannula Matas has suggested that this should be of especial construction in that it should contain not only a terminal but a lateral opening;

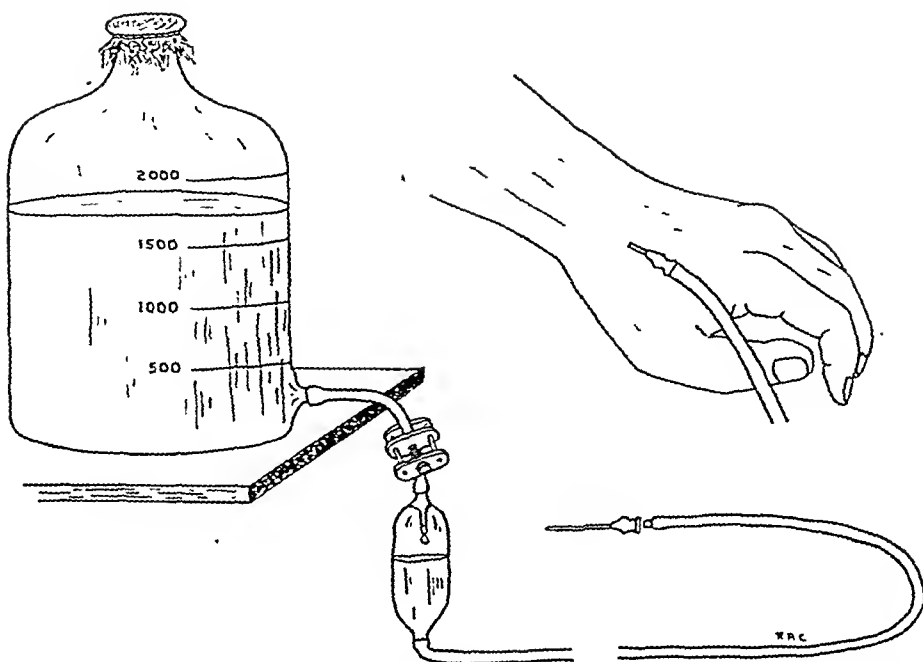


FIG. 34. Apparatus and method of giving continuous-drip intravenous infusion as advocated by Gallie and Harris.<sup>1</sup> Reservoir illustrated at left of drawing consists of a pyrex glass bottle of 2000 c.c. capacity which is graduated and is provided with a side-arm outlet at the bottom; receptacle is made of resistance glass in order to withstand temperature of autoclave during sterilization. Neck of receptacle is covered with pad made of gauze and cotton and tied in place with piece of cord.

Device for measuring rate of flow consists of an elongated glass capsule incorporated in which is a dropping tip; capacity of this capsule is much greater than that of ordinary dropping tube, to which it is otherwise quite similar. The cannula for introduction into a vein consists of No. 17 blunt-tipped gold needle. In the use of this apparatus the small veins on the back of the hand or the wrist are preferred rather than the larger veins at the bend of the elbow. Needle is inserted after formal dissection of vein. The hand is then conveniently placed upon a pillow and fixed in place by folded towels placed over the hand and forearm and secured to the pillow by means of safety pins.

Gallie and Harris do not advise use of glucose solutions in this apparatus because of tendency of such solutions to produce venous thrombosis. If glucose solutions are considered necessary they should be given relatively rapidly and should be followed by the use of physiological salt solution. Physiological salt solution or Locke's solution are the most satisfactory fluids. Such solutions have been used continuously for as long as ten days without changing cannula and have been injected as slowly as 500 c.c. in twenty-four hours.

<sup>1</sup> Gallie, W. E., and Harris, R. I. Continuous intravenous administration of physiological salt solutions. *Ann. Surg.*, 91: 422, 1930.

such a cannula may be permanently tied into the vein, the vein being securely ligated distally. The operative area is now covered with a sterile dressing, and the needle or the cannula and tubing are secured to the arm by adhesive plaster strips so the cannula or needle maintains a position essentially parallel to the long axis of the arm and is not angulated in relation to the vein used.

A glass connection is interpolated in the delivery tube leading to the cannula or needle at a distance from the latter of about 6 in. in order to allow recognition of any back flow that may ensue due to blockage of the cannula.

In introducing the cannula or needle and at all times subsequently care must be taken to avoid the introduction of air into the veins. This is accomplished in the first instance by completely filling the cannula or needle with solution just prior to its introduction and later by frequently determining the level of solution in the reservoir and the connecting system of tubes.

The rate at which the solution should be allowed to flow varies, of course, with circumstances, but may be about 40 to 60 drops to the minute in the average case. Half this rate may be adequate in the presence of an improving pulse rate and a rising blood pressure; twice such a rate may be inadequate when the pulse is rapid, small, thready, and easily compressible.

The temperature of the solution used may be varied in accordance with the condition of the patient. A temperature essentially that of the room may be used in cases in which the body temperature of the patient is elevated and increasing, whereas when the patient's temperature is hypothermic or falling a temperature of between 100 and 104° F. at the cannula is not too high.

Various solutions have been proposed for use in the continuous intravenous drip apparatus. Dextrose solutions of approximately 5 per cent are especially valuable, such solutions being essentially isotonic with the blood and being capable of supplying relatively large quantities of nutriment.



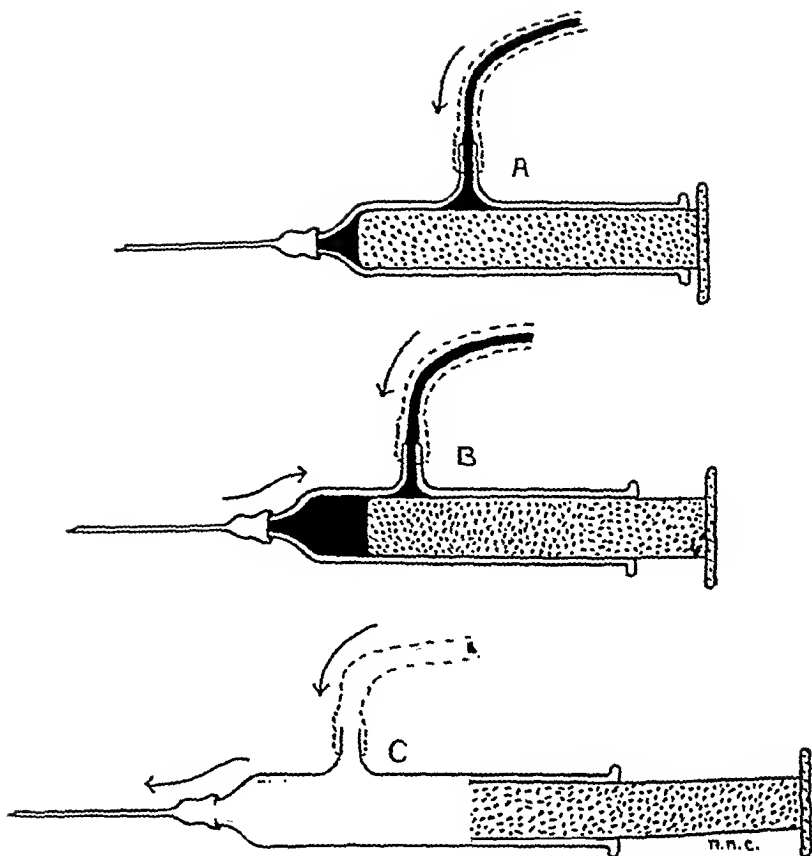


FIG. 35. All-glass syringe with side-arm blown in the barrel, illustrated above, is a very convenient device for use when making intravenous injections; solution to be injected is conducted by rubber tubing into side-arm of syringe. With plunger pushed into syringe as far as it will go, as at A, side-arm is blocked by piston, and no fluid flows; in this position lumen of vein is sought with needle. When needle pierces vein wall venous pressure forces blood into end of syringe, and unless mechanical pressure is maintained on piston, syringe barrel gradually begins to fill as at B; solution cannot yet flow through side-arm because it is still blocked by piston. After barrel of syringe has filled somewhat more, however, as at C, end of piston no longer blocks side-arm, and solution flows. When it is desired to discontinue flow, piston is simply pushed into barrel so as to block side-arm; after this a few drops of blood can be aspirated into syringe before withdrawal in case solution is irritating and one wishes to avoid all possibility of extravascular leakage.

This device is of especial value when veins are small and difficult to locate. It also serves as an excellent device for use in continuous drip infusions in which case it can be conveniently fastened to arm with adhesive strips and left as long as desired. When using such a device needle can be cleared if desired, without withdrawing, by manipulation of piston—another advantage.

A small chain, not shown in these schematic diagrams, connects syringe barrel with piston and prevents displacement of piston beyond position shown at C.

In cases receiving the intravenous drip at a rate of from 30 to 40 drops per minute, from 4 to 5 l. of fluid are provided during the course of twenty-four hours; a 5 per cent solution of glucose in such amounts contains, accordingly, from 200 to 250 gm. of glucose. Figuring the caloric equivalent on the basis of 3.75 calories to the gram of dextrose, the number of calories thus provided amounts to from 750 to 937.

3. *The Occurrence of Systemic Reactions Following Intravenous Infusion:* There can be no doubt that even in the presence of scrupulous aseptic technique the most careful preparation of glass-ware, rubber, connections, and solutions, and delicacy and precision in operative manipulations a certain number of patients will develop reactionary phenomena following the institution of either continuous drip or massive infusions.

The reactionary phenomena under discussion consist of (1) a chill, which is usually definite and accompanied by marked shivering and shaking, and (2) the occurrence of fever, the temperature of the patient rising within a period of two hours to 103.5 or 104.0° F. when taken by rectum. During this period the extremities are cold and possibly cyanotic, due to capillary and venous stasis, and the arterial pressure falls somewhat, the pulse becoming irregular. Such reactions are usually not serious, and recovery is the rule. The condition of the patient usually begins to improve within the course of a two-hour period, and complete recovery is established in from six to twelve hours. Such reactions seem to exhibit no tendency to recurrence and to be self-limited in their course. They rarely give cause for serious concern, but may occasionally be very alarming, or even cause death.

There has been a rather general belief that such reactions follow the introduction of glucose solutions more frequently than the introduction of solutions of sodium chloride, and that the addition of insulin to solutions of glucose seems to have little or no influence on the frequency of such reactions.

Much speculation and considerable research has been directed toward an understanding of the etiology of this

phenomenon. Among the specific factors which have been suggested as of etiological significance are (1) hydrogen ion concentration of solutions, (2) temperature of solutions, (3) speed of injection, (4) particulate suspensions in the solution (especially material derived from improperly prepared rubber tubing), (5) chemical substances dissolved from the walls of glassware, (6) and various more vague factors such as individual susceptibility and specific abnormalities due to the presence of disease processes.

In a series of interesting experiments Rademaker has presented evidence to show that none of these factors can be incriminated as of constant etiological significance. Following the lead of Seibert, Rademaker believes, however, that he has been able to discover the etiological factor in the water from which the intravenous solutions are compounded; neither the temperature of the water nor yet the hydrogen ion concentration of the water, but rather so-called "pyrogenic" substances in the water are responsible for the reactions. Because these substances are alkaline in reaction solutions containing them are apt to be alkaline, and hence alkaline solutions are somewhat more apt to produce reactions than acid solutions. Both Seibert and Rademaker believe that the pyrogenic substances are produced as a by-product of the growth of certain river bacteria, the bacteria themselves not being necessarily toxic, and that it is possible to rid water of these substances by distillation in a properly constructed apparatus which makes use of a "multiple baffle plate spray catcher" or a "Glinsky tube" to prevent the substances from "distilling over" mechanically. Because, however, of the fact that water so rid of pyrogenic substances may soon become contaminated again (within 48 hours) through exposure to the air or through growth of bacteria not eliminated by the process of distillation, water which has been carefully prepared does not remain nonpyrogenic unless it is immediately sterilized and sealed in a suitable container.

If the observations of Seibert and Rademaker are correct post-transfusion reactions can now be considered a relic of the

past. All that is required to prevent them is a single distillation in a still of proper design followed by immediate sterilization of the water by heat and preservation of its sterility by sealing in a suitable container.

Because of the fact that the ultimate nature of post-infusion reactions is obscure the treatment of an already developed case is purely symptomatic.

The maintenance of the body heat by the application of hot water bottles, and possibly the addition to the infusion solution or the separate hypodermic injection of adrenalin or pituitrin may be tried.

#### V. THE USE OF NORMAL SALINE SOLUTION FOR PURPOSES OF HYPODERMOCLYSIS AND INTRAVENOUS INFUSION

Saline solution for hypodermoclysis or intravenous infusion is usually prepared in a strength of 1 per cent. The physiological or isotonic solution is one containing either 0.85 or 0.9 per cent of sodium chloride and is so-called because such a solution when added to an emulsion of erythrocytes causes the latter neither to decrease in size (crenate), nor to swell, (lake). Since these percentages are, however, so near 1 per cent and since during sterilizing processes more or less water is either added to, or driven off, from solutions which previously may have been made up with the utmost accuracy, it is customary to regard a 1 per cent solution as to all intents and purposes isotonic.

It must be remembered, nevertheless, that such a solution contains not the same amount of sodium chloride as the blood plasma but represents a much higher concentration, for the tonicity of the blood serum is maintained by a number of sugars, salts, and other kinds of substances capable of exerting osmotic tensions, whereas in the physiological sodium chloride solution the sodium chloride alone must make up the required osmotic pressure and must be present in sufficient quantities to equal the total effect of all those other substances normally subserving such a function.

The addition of a physiological salt solution to the blood stream, therefore, increases both the total and the relative amount of sodium chloride within the blood vessels and is potentially capable of causing considerable harm. It has been shown by Hoeszli<sup>20</sup> that following the massive infusion of physiological salt solutions into guinea pigs the heart and kidneys of these animals undergo degenerative fatty changes within six or eight hours. The danger of sodium poisoning has been discussed elsewhere.

The osmotic relationship between the blood stream and the fixed tissues of the body is only imperfectly understood, but it has been for a considerable length of time a matter of clinical experience that degenerative changes in the kidneys are capable of interfering with the normal process of eliminating excess sodium chloride from the blood stream. In connection with this renal change and also in certain other toxic conditions not well understood active salt retention occurs, and the administration of still more salt serves to upset the balance even further with the production of a local dropsical condition or a generalized anasarca.

The solutions of Ringer, Locke, and Hayem are modified salt solutions in which an attempt has been made to approximate more closely the concentration of substances found in normal serum, but they all contain an excess of sodium chloride and consequently are all open to the same general objections.

In the use of sodium chloride solutions either as a vehicle for water administration or as a deliberate means of adding sodium or chloride ions to the tissues, due consideration should be paid to the normal chloride mobilizing mechanisms of the body. Under normal conditions the chloride content of the blood is maintained at a relatively constant level. Calculated as sodium chloride, as is usual, the normal value for chlorides in whole blood is stated as 450 to 500 mg. in 100 c.c.; in plasma the value is 570 to 620 mg.; the variation in health is relatively slight.

Only a small part of the mechanism by which the constancy of the relationship between blood volume and chloride content is maintained is as yet known. The chlorides of the blood are, of course, originally derived by absorption from the gastrointestinal tract, and accordingly represent the chlorides contained in food and water. Usually a superabundance of chlorides is provided with the pabulum. They apparently pass unchanged through the stomach and do not undergo very rapid absorption from the small intestine, most of the absorption occurring low in the ileum and especially in the colon. The kidney provides elimination for the chlorides, and since more chlorides are normally absorbed than can be utilized a continuous process of excretion from the kidney takes place. The mechanism of balanced absorption from the gastrointestinal tract and elimination through the kidney, therefore, represents the fundamental equilibration.

Within the body, however, the chlorides undergo a secondary cycle of secretion and reabsorption. The secretory part of the cycle occurs in the stomach in connection with the secretion of the gastric juice; the chlorides are secreted into the lumen of the stomach in the form of hydrochloric acid. Neutralized in part by the alkalis and proteins of the food, the gastric contents, still acid, are discharged into the duodenum, at which point they come into contact with the strongly alkaline succus entericus and are immediately completely neutralized. From this point they are passed on as neutral chlorides in company with the chlorides primarily taken with the food to be absorbed by the lower small bowel and the colon.

These facts help to explain some of the disturbances which occur as the result of disease. Inasmuch as the excessive intake of chlorides is offset by urinary excretion, increases in blood chlorides, hyperchloremia, can ordinarily result only in cases in which the excretory activity of the kidney is disturbed. Such a condition occurs in that type of nephritis characterized by chloride retention, and a part of the treatment of such a form of nephritis obviously consists in restricting the amount of chlorides ingested.

The opposite condition, hypochloremia, in which the blood chloride content is abnormally low, can occur, on the other hand, either (1) in connection with dietary restriction, or (2) in connection with loss of chlorides secreted into the stomach as hydrochloric acid. From the point of view of surgical practice, the latter mechanism is of especial importance. Excessive vomiting always calls for the administration of chlorides either rectally or parenterally to prevent undue loss of chlorides from the blood stream. The administration of such substances by rectum is, of course, eminently rational, because the large bowel is normally the place from which the absorption of the chlorides takes place.

#### VI. THE USE OF DEXTROSE (OR GLUCOSE) BY MOUTH, IN PROCTOCLYSIS AND IN HYPODERMOCLYSIS AND INTRAVENOUS INFUSION

The chemical formula for dextrose is  $C_6H_{12}O_6$ , the aldehyde derivative of a polyatomic alcohol and a monosaccharide. Its caloric value is 4.1. It is obtained by the action of an acid on starch; sulphuric acid was formerly used in the manufacture of this substance, but hydrochloric acid has been latterly substituted because sulphuric acid sometimes contains traces of arsenic.

Commercially, dextrose occurs in two general qualities: (1) the ordinary "commercial glucose" which is a refined but not a chemically pure substance and is suitable for administration by mouth or rectum only, and (2) the chemically pure product, "technical dextrose," which when placed in sterile solution is suitable for hypodermic injection or intravenous injection.

Commercial dextrose is a mixture of substances, a representative chemical analysis showing about 31 to 35 per cent of pure dextrose, 40 per cent of dextrine, usually some cane sugar, some maltose, and 20 per cent or more of water; the ordinary corn syrup of commerce which is sold under various trade names is a concentrated solution of impure dextrose.

For use by mouth or as a rectal drip either corn syrup or the solid commercial dextrose is simply diluted with a sufficient amount of tap water to make the required percentage solution, no further preparation being necessary.

When taken by mouth dextrose solutions, as strong as are usually desirable therapeutically, are so sweet that they readily become cloying unless measures are taken to prevent this occurrence. Usually patients tolerate relatively strong solutions of glucose if such solutions are made up with the juice of lemons and the mixture is taken ice cold. One pound of dextrose, representing 1000 large calories, can be stirred into a quart of boiling water, the juice of two lemons being added, together with their chopped-up rinds and the mixture being allowed to boil for a minute or two; this mixture, when chilled, is palatable for adults, though children may prefer it somewhat diluted.

It is commonly believed and taught that if more than 200 gm. of pure dextrose be placed in the stomach of a healthy adult some of it will very soon appear in the urine; undoubtedly this is true for certain individuals with a relatively low tolerance for dextrose, but Cori,<sup>21</sup> working with rats, and Sansum and Woodyatt,<sup>22</sup> working with dogs, found that no matter what amount or concentration of glucose was placed in the stomach of these animals and in whatever state of starvation the animals were tested, absorption was at a uniform rate of about 1.72 gm. per kilo of body weight per hour, and that glucose did not appear in the urine. It is interesting to note in this connection that on the basis of these figures more than twice as much glucose can be utilized by absorption from the stomach as from intravenous infusion per unit interval of time.

Thus Woodyatt, Sansum, and Wilder<sup>23</sup> have determined that a normal man weighing 70 kg. can receive and utilize by vein when resting quietly 63 gm. of glucose per hour. This represents 252 calories per hour or 6048 calories per diem. Translated into terms of 5 per cent solution, a normal man



would be able to utilize 1260 c.c. per hour; in 2.5 per cent solution he would tolerate 2520 c.c. Amounts in excess of the figures quoted are supposedly eliminated by the kidney without being utilized, and hence dextrose administered intravenously should be introduced reasonably slowly to prevent waste and the possible harmful results of elimination through the kidney.

Dextrose needs no digestive process to prepare it for absorption, since it is absorbed as such, and in its metabolism it places no strain upon the excretory apparatus, as it is completely metabolized to carbon dioxide and water. To a certain extent it is capable of being transformed into fat and it is also a protein and fat saver. Furthermore, regardless of the presence of diarrhea, all the dextrose supplied to the alimentary tract, with the exception of a very small amount indeed which may be split by bacteria in the intestinal canal, is absorbed; none is excreted.

Glucose for purposes of hypodermoclysis or intravenous injection may be prepared from either dry or syrup glucose. Suitable solutions are prepared by dissolving the desired amount of the glucose, usually 5 per cent, in distilled water. The solution is then put into a pressure sterilizer and is sterilized under 15 lb. pressure for thirty minutes. When large amounts of solution are prepared for stock purposes convenient amounts, usually 500 c.c., may be measured into separate flasks which are then plugged with cotton, sterilized separately, and used, one by one, as needed.

In connection with the use of dextrose for therapeutic purposes a word should be added with respect to insulin.

#### VII. THE PREOPERATIVE AND POSTOPERATIVE USE OF INSULIN IN NON-DIABETIC PATIENTS

To Thalhimer<sup>24</sup> belongs credit for having initially called attention to the use of insulin in the treatment of acidosis as it occurs preoperatively and postoperatively in cases not associated with diabetes. The use of insulin in the non-

diabetic patient depends upon the assumption that if insulin can perform the almost miraculous transformation for the better which it is known to be capable of performing in the patient suffering from diabetic acidosis, it should be effective in the often less severe forms of the condition due to other causes. That many have adopted this form of therapy is attested by a considerable laudatory literature which has accumulated on the subject in the last few years.

As in the case of many other forms of therapy a considerable experience with it, however, has brought to light some of its limitations and failings. Ringer<sup>25</sup> early demonstrated that in pancreatectomized animals one unit of insulin would bring about the utilization of 1 gm. of glucose, using the respiratory quotient as a standard of measurement; this is so, however, as has subsequently been discovered, only in the case of the depancreatized animal, since the relationship between insulin and glucose is by no means as simple as that existing between two chemical compounds which unite in a given ratio to produce a given effect. In fact, it is very doubtful whether insulin acts as a glycolytic agent, as such, at all for it has been definitely shown that insulin alone will not increase the breakdown of glucose within muscle tissue. In the light of the researches of Eadie, Mcleod, and Noble,<sup>26</sup> Macleod and Chaikoff,<sup>27</sup> and others, three effects of insulin have apparently been demonstrated: (1) it facilitates glycogen storage in the liver, (2) it produces a condition of blood concentration, presumably by increasing the affinity of the body tissues for water, and (3) it possibly converts the glucose into some more readily oxidizable hexose.

It has been appreciated from almost the first that whereas a combination of insulin with glucose is often most beneficial there are many cases in which a dangerously low level of blood sugar is rather rapidly produced and that this occurrence is of much greater frequency in the non-diabetic than in the diabetic patient. Andrews and Reuterskiold<sup>28</sup> have shown that this effect is much more marked in dehydrated patients

than in those in whom the body fluid level is maintained by the administration of suitable quantities of fluid, and this is in direct accord with what might be expected from the blood concentrating action of insulin previously mentioned. Administrations of a well-balanced combination of insulin and glucose, which in the otherwise dehydrated patient readily produce a fall in the blood sugar level to 40 or 50, produce in the patient properly hydrated a fall to a level of only 80 or 90, which, of course, is well within safe limits.

The action of insulin is not sufficiently well understood at the present time to warrant its promiscuous use in the non-diabetic patient either preoperatively or postoperatively. It is indicated in cases in which there is reason for believing that the sugar metabolizing functions of the pancreas are impaired, but in other cases it is probably better to assume that the patient is suffering from no lack of ability to utilize carbohydrates but rather from a lack of such substances to metabolize. If insulin must be used, or if the medical attendant believes that such use is indicated in any given case, it is certainly incumbent upon him to realize that he is invoking the aid of a two-edged sword and a weapon therefore which must be handled with the utmost circumspection. Frequent blood sugar examinations cannot be omitted with impunity, and the presence of a small amount of sugar in the urine is not to be regarded as altogether a safe assurance that the patient is suffering no ill effects from therapy, since, as is well known, sugar acts as an excellent diuretic, and dehydration is one of the factors most to be dreaded in general as well as in connection with insulin administration as previously noted.

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## RESEARCH INTO THE FORMATION OF AUTOSYNTHETIC CELLS

WITH SPECIAL REFERENCE TO FERTILIZATION, THE PRODUCTION & GROWTH  
OF CANCER CELLS & THE CAUSE OF FATTY DEGENERATION\*

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IT is my first and most pleasant duty to put in words my sense of appreciation of your invitation to me to deliver the William Potter Memorial Lecture. My regard for Chevalier Jackson is so great that his invitation was my command.

The research here presented, was carried out in the laboratories of the Cleveland Clinic Foundation, in collaboration with Maria Telkes, PH.D. and Amy F. Rowland, M.A. I wish also to make acknowledgment of the advice and assistance received from Professor Dayton C. Miller and Professor W. R. Veazey, of the Case School of Applied Science.

There is much evidence that cancer cells vary greatly in their activity, in comparison with the cells of the host.

1. Cancer cells show a change in nucleus plasma relation, as compared with the host.

2. The conductivity and capacity, in actively growing cancer are higher than in the host.

3. Opinions differ widely, as to the rate of metabolism in cancer, as compared with that in the host.

4. Many cancers and tumors are more sensitive to radiation than the host.

5. Cytologists, notably Broders, have been able to some extent to base a prognosis on the degree of differentiation of the cancer cell.

An interpretation of the conductivity and capacity of cancer tissue, as compared with the host, must be made tentatively, since in the cancer mass there is a greater preponderance of cells and this in itself would increase the conductivity and the capacity. The only safe comparison would be the measurement of the conductivity and capacity and metabolism of a single cell.

At this time we propose to consider the facts that would be harmonized by the conception that cancer cells are reduced normal cells, that their success in growth is due to the fact that the cells of the host are differentiated, that their energy is spent within the cell in function while the cancer cell having no inner function expends its energy in growth only.

The cancer cell, like the cell of the host, is made up of proteins, lipoids and electrolytes, the chief difference between a cancer cell and the corresponding normal cell being that the energy of the normal cell is used principally in the performance of the specific work for which the cell was differentiated, while the cancer cell uses its energy principally for growth, and little or not at all for function.

Between the normal cell that may grow and the cancer cell that may perform some specific function, there is a vague zone of identity.

\* The William Potter Memorial Lecture, 1931, Jefferson Medical College, Philadelphia.



Within this zone in certain cases the cancer cell may even perform a specific function identical with that performed by the host. Thus, as Wells states, even "metastatic growths of thyroid tissue, will produce thyroïdin in any part of the body; liver carcinoma metastases produce bile; tumors from the choroid or from pigmented moles produce melanin." In certain cases, malignant cells bear certain chemical characteristics of the parent tissue, as in the case of the high content and quality of the lipoids in hypernephroma, and the content of iodine in cancer of the thyroid, while over-function of malignant tissue is seen in melanoma of the skin (Ewing).

Like normal cells, cancer cells are killed by radiation and by loss of their blood supply; they grow slowly in old age; they are stimulated by irritation; they become infected; they undergo fatty degeneration; they take vital stains in some relation to their rate of growth and activity; and they show changes in electric conductivity, capacity, and potential, in relation to changes in their growth or functional energy. Like normal cells, cancer cells show a relation between rapidity of growth and degree of differentiation. The more differentiated the tissue, the less energy is left for growth, while the most highly specialized cells, the brain cells, have completely lost the power of growth. In normal tissue, the opposite extreme is seen in the contrast between embryonic and adult tissues. The energy of a fertilized ovum is as completely used in cell division as that of cancer cells in growth. As differentiation progresses and tissues and organs form, there is a gradual increase in the use of the energy of the cells for the performance of function; in other words, as function increases, growth diminishes. And finally, function and maintenance of structure use up so much of the energy of the cell that none is left for growth: the adult status is attained. It is obvious that cancer cannot develop in early fetal life, for fetal growth-energy is more vigorous

than cancer growth-energy. Such is the relation between the pure cancer cell, whose principal or only use of energy is growth, and the partially differentiated cells in benign tumors: that is, in benign tumors and cancer and under normal conditions an identical principle of energy transformation is manifested. A cancer cell, therefore, is probably a normal cell in which that part of its structure which used its energy for its particular function has been transformed into a structure which uses its energy for growth, and once capacity for growth has been established in a cell, at the expense of function, that cell would be expected to continue to grow and to multiply at the expense of its neighbors having lower growth-energy.

It is important to note that without physical, chemical, or radiation injury, the energy of no normal cell is transformed from the higher form used for function into the lower form used exclusively for growth. Thus, an ameba could not have a cancer; it already has continued growth-energy.

Physical, chemical, and radiation influences have great power of modifying both function and form of cells. This fact brings us squarely to the crux of our problem, namely, how can we divest differentiated cells of the side chains of the molecules of their lipoids and proteins which evolution has added to the simple undifferentiated cell, thus converting the simple growing cell into a cell with some other function.

If there were some way by which we could take from normal cells the fractions necessary for growth and leave behind the fractions for function, we would advance a long step toward the solution of the problem.

In Nature we have well established examples of cells that exist for a time for growth only. In the case of the sex cells, the energy, after fertilization has been effected, is transformed at first into growth-energy alone. The ameba divides into two identical amebae, each going its

own way. If the millions of cells of the rabbit should, like the ameba, divide at the same moment, there would be, as in the case of the ameba, two rabbits, but inseparable. This dilemma in higher animals has been overcome by assembling two essential fractions, bearing opposite signs of charge (as stated by Keller), that have been kept separate from each other until the biologic moment for the formation of a new animal arrives. On the bringing together of these fractions in the sex cells of animals bearing opposite signs of charge, a vigorous coalescence takes place. The sex cells which, according to Keller, bear opposite signs of charge, like all living cells, contain three essential constituents, electrolytes, proteins, and lipoids. The sex elements bearing the formula of their complicated parental protein and lipid molecules, develop into functional differentiation. Growth wanes as differentiation proceeds. An embryo could have no cancer, for, as stated, all the cells of the embryo have a vigorous growth energy, greater than that of cancer cells. Theoretically, embryo cells would eat the cancer cells; they would become the "cancer" of the cancer cells, as the result of successful competition with the cancer cells for energy. As the embryo man develops as a fetus, as an infant, as a child, a gradually increasing proportion of the total energy is taken by function; while growth, by so much, is slowed down. With this gradual transference of energy into function and withdrawal from growth, the chances for pathologic growth increase. That a tumor or cancer cell is not as vigorous as the embryonal growing cells of the organism is seen by a comparison of certain physical constants, such as conductivity, capacity, and potential; by metabolic rates; by the organizing power of the lipoids of fetal tissue, as contrasted with the organizing power of the lipoids of cancer; and by contrasting the iodine number of the lipoids of fetal tissue with the iodine number of the lipoids of cancer. On the basis then of such a conception

of the relation of energy of the tissue to cancer growth, one would not expect to find cancer in the fetus with its high growth energy; nor would one expect to find cancer in those adult tissues and organs having a high metabolic rate, such as muscle, grey matter of the brain, and the adrenal cortex. On the other hand, one would expect cancer to appear commonly in tissue of low metabolic rate, such as epithelial tissue, connective tissue, bone, and lymph glands.

Many observers, notably Cohnheim, have discussed the resemblance between the growth of a fertilized ovum and the growth of a cancer cell. Klefs proposed the hypothesis that a cancer cell is the result of "fertilization" of a normal cell by a leucocyte. Now since in the growth of a cancer cell there admittedly is an analogy to fertilization, my associates and I approached the problem from another angle, namely, we proposed to reduce normal cells from the more complicated molecular structure required for function to the simpler molecular structure required for growth; in other words, we proposed to reduce the adult cell whose energy is used for function toward the simpler embryonic type in which the energy of the cell is used for growth only.

In the entire organism there is normally not a single cell endowed with no purpose or function; in other words, normally there is no cell endowed with growth-energy alone. The overwhelming experience of the clinic has been expressed no better than by the statement of Billroth that "Cancer never appears spontaneously in uninjured tissue." This is also the general conclusion of students of cancer.

We may safely start then with the premise now widely held, that cancer cells are normal cells so structurally altered by mechanical, chemical, or radiant energy that they are partially or wholly bereft of their power of transforming energy into function, but have not lost the power of transforming energy into growth; in other words, a cancer cell is a reduced normal

cell existing at a level above fatty degeneration and death: a cancer cell is an injured normal cell. As stated, this conception is most commonly accepted by students of the cancer problem.

As we have stated, there are three fractions of cells, each of which is essential to their formation, growth, and function. These fractions are electrolytes, lipoids, and proteins. The sex cells carry these three fractions so completely that growth and differentiation are carried to completion in the image of the parents.

In the laboratory, it is obvious that such a faithful reproduction cannot be achieved, as the delicately poised side chains making up the half living lipid molecule, and the delicately poised fractions of the chemically versatile protein molecules could not be separated without depriving the cell of the power of performing its specific function. Nevertheless, if we were to choose an organ whose structure and function are on such a high level that although the great lipid protein molecules would support the loss of many side chains, there would still be left enough of the lipid and the protein structures to form a lower form of cell, we would choose the brain. The brain has the largest proportion and the highest order of the lipoids which, as contrasted with the proteins, have in themselves the power of oxidation and which also bear within themselves structures that may well be the forerunners of cells, e.g., negative glycerol and choline, and positive fatty acids held in the fields of phosphorus and potassium. The brain lipoids and the proteins from the brain or any other organ together with electrolytes, when mixed together should unite vigorously, for the lipid and the protein bear opposite signs of charge as do sex cells, and these should unite to form a low or reduced order of cell which would exhibit the fundamental characteristics of living protoplasm, viz., irritability, reproduction, and respiration.

Many attempts have been made to pro-

duce artificial cells. Such phenomena as division, growth, ameboid movement, and other phenomena have been observed and described by many investigators, notably Bastian, Beutner, Butschli, Herrera, LeDuc, Lehmann, J. Loeb, MacDougal; but despite the painstaking efforts, supported by profound knowledge and brilliant technique, no artificial cell hitherto reported has had the power of energy transformation, the most fundamental characteristic of a living cell.

The artificial cells produced by these investigators may show a nucleus and inner organization, they may divide, show ameboid movement, and superficially, they may resemble living cells, but they cannot of themselves transform energy. The nearest approach to normal cells seems to be those cells constructed by MacDougal, in which a difference in potential was maintained on the opposite sides of the membrane.

The extent to which our expectations regarding the formation and function of such autosynthesized cells have been realized, is summarized in the following brief report of experiments performed in collaboration with Maria Telkes, PH.D. and Amy F. Rowland, M.A.

From the organs of freshly killed normal animals, the lipoids and proteins of the brain were extracted and the ash obtained. By mixing together the brain lipoids, the brain proteins, and a solution of the brain ash, or of the electrolytes contained in the brain, the process of fertilization in Nature by the uniting of the spermatozoön and the ovum was crudely imitated.

On observation of this mixture of brain lipid, brain protein, and solution of electrolytes under the microscope, we noted immediate activity of organization. Cell-like forms appeared and grew slowly. They multiplied, sometimes by budding, and sometimes by direct division. These cells were nucleated; they took vital stains; they consumed oxygen; they gave off carbon dioxide and they produced urea. Under a high magnification, free movement

of granules and a movement, not unlike the Brownian movement, was seen. Their activity was increased by electric stimulation. Some of these have continued as active cells, for four months.

Exactly the same technique was carried out for the other organs of animals. The lipoids and proteins of the various organs other than the brain were extracted and the ash obtained, but upon mixing the lipoids, proteins, and a solution of the ash of these various organs, only feeble or no power of organization, was seen.

We next observed the effects of adding the brain lipoids to the proteins and solutions of the ash of each of the other organs. Immediate organization was observed. The cell-like structures that were formed took vital stains; they grew in size; they multiplied and they showed respiration.

This experiment revealed clearly that the brain lipid is unique in being the possessor of a structure that in collaboration with the electrolytes has the power of organizing the proteins of any organ.

As we have stated, these autosynthetic cells showed vital stainability. They grew and multiplied. They showed internal organization such as a nucleus, granules, etc. They varied considerably in size. They had respiration, their oxygen consumption running as high as 1.4 cu. mm. per hour per 2 c.c. of cell mixture, over a period of five hours, the respiratory quotient for this period ranging from 0.7 under normal conditions, to 0.98 when glucose was added. Some of these cells were observed for a period of nine hours and many photographs, showing the changes in their form, were taken. The form of the cells seemed to depend on the pH of the electrolyte solution, ciliated cells being always produced in a solution of pH 7.5.

While we were carrying out the effects of adding various "food" substances to the cells, it was found that glucose increased the metabolism of the cells, while the various culture materials, such as beef broth, agar, blood serum, etc., showed little or no effect. It is necessary, however, in order to

keep cultures "alive" over a period of time, to "feed them" by the occasional addition of protein. When adrenal protein was added the cell immediately assumed the appearance of an ameba and pseudopodia, like those of an active ameba, were thrust out. The usual manner of movement was by the thrusting out of a loop of fiber-like substance from the body of the organism, into which loop the contents of the organism, the granules, etc., seemed to flow, the organism moving in the direction of the flow.

Of special significance was our finding that autosynthetic cells were not formed in the brain-lipoid-brain-protein-electrolyte mixture of dogs which had died from distemper. Of singular significance is the observation that in rabbits which had died of exhaustion from insomnia, the power of cell formation was lost.

On the addition to the brain lipoids and proteins of an electrolyte solution identical with the brain ash solution, with the exception that the potassium salt was omitted, cell formation was delayed and the cells differed in form from those found in the complete brain ash solution. It should be noted that the lipoids themselves held absorbed potassium ions. Could all the potassium be eliminated, it might be that the power of organization of cells would be entirely lost.

In collaboration with Dr. Otto Glasser of the Cleveland Clinic Radiation Research Laboratory, we subjected the brain lipid to intense radiation before it was mixed with the brain protein and electrolyte solution, and we found that it had lost the power of organization. No cells were formed. The radiated lipid material assumed the aspects of a quite different substance. Small globules, apparently resembling neutral fat, appeared, suggesting that radium dislocates the metal elements, viz., the potassium and phosphorus molecules which bind together the delicately poised elements of the cell. Radiation of newly formed cells broke them down. On the other hand, radiating the protein

had no effect. Autosynthetic cells were formed with radiated protein, and non-radiated lipid as freely as with non-radiated protein. It would seem, therefore, that the lethal effect of radiation must be exerted on the lipid element of cells including cancer cells, the vulnerable points in the lipid being probably the phosphorus and potassium atoms.

Cataphoresis measurements have been made from which the electric charge of the protein itself, the lipid itself, and the organisms, have been calculated. There was a marked potential difference between the lipid and the protein, and the charge on the cells has been found to vary from 50 to 70 millivolts.

Direct measurements of the electric potential difference of the cells and of the nucleus and cytoplasm were made by introducing electrodes into them. The nucleus was found always to be positive with relation to the cytoplasm, the difference of potential varying between 20 and 30 millivolts.

When "old lipoids," that is, when lipid material that had been kept over a number of weeks was used, we observed that instead of organized autosynthetic cells, fatty droplets were formed. These fatty droplets, which were similar to those seen after the lipid had been radiated, were seen also after a cyanide or a toxin was added to the lipid mixture and after the autosynthetic cells were deprived of oxygen, asphyxiated. This phenomenon apparently corresponds to fatty degeneration and may be produced at will. At Clowes' suggestion, oxygen was bubbled through active lipid with the expectation that the essential fatty acids would be immediately saturated and rendered inert. This prevented the formation of cells, as anticipated.

The effects of the addition of various agents to the lipid—protein—electrolyte mixture were as follows:

Both the potential difference and respiration were decreased on the addition of an anesthetic (urethane). (N.B., the effect

of ether and chloroform could not be tested as the addition of these substances made the measurement of oxygen consumption impossible.

The addition of salts in various concentrations affected the potential difference of our autosynthetic cells in a manner strikingly similar to the effect of the same concentrations on the potential differences of bacteria (Brown and Broom).

The potential difference of the autosynthetic cells was increased on the addition of thyroxine, of sodium iodide and of glucose.

The potential difference and the respiration were decreased on the addition of morphine.

On the addition of a small amount of strychnine or of alcohol (3 to 5 per cent) the potential difference was increased. On the addition of large amounts of either strychnine or alcohol (50 per cent), the potential difference was decreased. On the addition of a cyanide or of a toxin the potential difference was decreased to zero.

A mixture of the lipid and protein of a human brain with the electrolyte solution produced a highly organized cell with active division. A mixture of the lipoids extracted from a cancer with proteins and electrolytes produced a bizarre appearance characterized by the presence of many fatty droplets.

Measurements of the iodine number showed that brain lipid has the highest iodine number and cancer tissue the lowest of any of the tissues measured. On standing or on being oxygenated, as suggested by Clowes, the brain lipid lowers its iodine number.

Of special significance was the finding that the brain-lipid-brain-protein-electrolyte mixture produced urea.

From these experiments it is seen that the autosynthetic cells exhibit the three fundamental qualities of living protoplasm: irritability, respiration, and reproduction.

While these results afford no final proof as to the mechanism of the formation of cancer cells by changing the structure of living cells, it offers an analogy and a parallel.

The value of a theory lies in the number of phenomena it interprets and in the number of productive hypotheses it suggests.

What known facts are harmonized by this point of view regarding the formation of cancer cells?

First of all we have shown by our experiments that cells of the highest order with a high degree of differentiation may be reduced to cells of a lower order having only growth and no function. One could suppose that comparable physical changes might be wrought in cells in situ by repeated physical, chemical, or radiation injury, even to the point of a complete breakdown and resynthesis in situ; in other words that any cause which produces a change in the potential of the cells might result in a partial change of the side chains, whose construction and presence depend on an adequate electric potential.

The potential in any given cell may be lowered by any change of the structure of the cell which falls short of a death-producing change with the resynthesis of the cell to a status below that of function and above that of fatty degeneration, namely, at the level of growth only. Again, one may interpret the effect of infection and its toxins on the basis of the behavior of our autosynthetic cells when toxins are added to the brain-lipid-brain-protein-electrolyte mixture. In our experiments this addition of a toxin interfered with the formation of the autosynthetic cells and induced fatty degeneration. In like manner the local toxins of a chronic infection of a tissue might, by chance, cause just enough impairment of the organizing power of the lipoids in the normal cell to reduce the differentiated cell to a level below that of the normal cell, to that of a cell with growth only, or a cancer cell.

There are, however, other chemical causes of cancer than those produced by bacterial toxins. Cancers are especially prone to form in the presence of acid secretions, as for example, in the acid stomach and the acid large intestine, as

contrasted with the almost complete immunity of the alkaline small intestine. Cancer tends to appear on mucous membranes which are chronically infected and show acidity, as on the cervix in chronic cervicitis, associated with, or without lacerations; in the bladder in the presence of acid urine, especially when it is associated with calculus.

Here obviously we have the factor of a change in the hydrogen-ion concentration. In our experiments it was shown that a change of the pH to above or below an optimum level lowered the power of the lipoids to form autosynthetic cells and a like change in the pH of the autosynthetic cells already formed caused a lowering of their form to a lower dynamic level. So we may think of a continued change in the pH as a strong factor in reducing the highly differentiated molecules of the normal cells to a lower level, that of growth only; i.e., to the cancer level.

Then again there is a not inconsiderable group of cancers caused by radiation: solar radiation, x-ray and radium radiation, and even possibly by mitogenetic radiation. Our experiments on the effects of radiation on the lipid fraction of autosynthetic cells showed a progressive lowering of the organizing energy-transforming power, exhibiting every grade of change down to fatty degeneration and total loss of the power of forming cells. This offers one interpretation of the incidence of cancer following radium and thermal burns, and very likely of the effect of excessive solar rays.

It may be argued that radiant energy causes cancer by first producing scars; but a scar is a sequel to the reduction in the level of differentiation of the cells affected by radiation toward malignancy or fatty degeneration or death.

What analogies or parallels do this theory and our researches offer as to the dynamics of the cancer cell? It is generally thought that the cancer cell has abnormally great vigor and high dynamic qualities, for it always kills its host, there-



fore it would appear to be a stronger cell with respect to its dynamic power than any normal cell; and yet the conception here proposed implies that the cancer cell is a cell of lower dynamic order and that its existence is possibly due to a partial lipid degeneration of normal cells. Cancer in its very origin enjoys an advantage not possessed by bacteria: the cancer cells being derived from the cells of the host set up no antibodies in their host; they are to a great degree in chemical and physical equilibrium with their host. The cells of the host and the cells of the cancer fraternize completely so the cancer unlike bacteria encounters no resistance in the host. That cancer cells are not super-cells as to their dynamics is seen from the fact that, as we have stated, cancer cells cannot compete with the growing power of embryonic tissue, for no cancer exists in embryonic life.

Again, cancer cells are decisively defeated by all the tissues and cells having a higher metabolism, such as muscle cells, heart muscle, voluntary muscle, smooth muscle. Cancer cannot attack the cells of a normal thyroid or those of a hyperplastic gland. Cancer does not attack the active brain cells. Thus cancer is inferior in energy to the vigorous fetal period and to the more active cells throughout life. Cancer cannot arise spontaneously in undamaged tissue, but arises after a certain degree of reduction of vigor by virtue of age; and even then it appears principally in the tissues or organs of a lower dynamic order. But cancer cells arising in early life or in vigorous individuals usually show a higher order of growth-energy. This would be expected on the basis of our experiments. In the aged, cancer grows slowly. It seems as old and as senile as its host.

On the other hand, normal cells have but little growth energy but possess great functional energy, hence a relatively low order of growth-energy in cancer cells is required to compete successfully with the very low growth-energy of differentiated

cells. Hence there comes the suggestion that the overwhelming success of cancer cells in destroying the body is due to "unpreparedness" for growth competition on the part of the tissues and organs rather than to a higher order of dynamic attack.

Another pertinent consideration is that in the formation of autosynthetic cells the quality of the lipid fraction extracted from the various organs and tissues shows in its power to effect the synthesis of cells the dynamic level of the tissue from which it was obtained.

We have seen that the lipoids extracted from the brain have the highest power of forming autosynthetic cells; that the lipoids from other organs have little or no power of organization and especially is it significant that the lipoids extracted from cancer are of the lowest order as compared with those extracted from normal organs or tissues. Cancer lipid can form no semblance of cells, but is of the order of neutral fat. The significance of the fact that cancer cells are largely anaërobic is not now discussed.

Finally but by no means of least significance is the fact that the iodine number which is an index of the power of a substance to create oxidation, to transform energy, showed the lipid extracted from cancer to have negligible powers of oxidation. Cancer cells, therefore, seem to be of a low order, just as the autosynthetic cells are of a low order.

Normal cells show respiration, irritability, and reproduction. Autosynthetic cells show respiration, irritability, and reproduction. Autosynthetic cells and cancer cells alike are cells which have been reduced below the level of specialized function but lie above the level of fatty degeneration. That is, the autosynthetic cell and the cancer cell, like the fertilized ovum, lie in the zone of growth alone.

No final conclusions are drawn.

#### PROPERTIES OF AUTOSYNTHETIC CELLS FORMED IN THESE EXPERIMENTS

Nuculation.

Growth.

Division by (1) fission, (2) budding.

Respiration, respiratory quotient, average 0.8.

Stainability.

Motility.

Production of urea.

Electric charge, average 50 millivolts.

Difference of potential between cytoplasm and nucleus, average 20 millivolts.

Disintegration when potential difference reaches zero.

Decreased potential and respiration on addition of narcotic or anesthetic.

Increased potential on addition of thyroxin, of sodium iodide, of glucose.

Decreased potential and respiration on addition of morphine.

Increased potential on addition of small amounts of strychnine.

Decreased potential and respiration on addition of large amounts of strychnine.

Increased potential on addition of alcohol, 3 to 5 per cent.

Decreased potential on addition of alcohol, 50 per cent.

Decrease of potential to zero and cessation of respiration on addition of cyanides and of toxins.

Decrease of potential to zero and cessation of respiration after radiation.

Tenure of "life" for two and one-half months (to date) by repeated addition of protein to culture.

Radiation of lipoids separately prevented formation of cells on mixture with protein and electrolytes.

Radiation of protein and of electrolytic solution separately had no effect on cell formation.

After exhaustion of rabbits by prolonged insomnia or by certain diseases bizarre forms were produced not at all resembling cells formed from lipoid and protein of normal brains.

After radiation, exhaustion, and asphyxiation, fatty droplets appeared suggesting the occurrence of fatty degeneration.

Lipoid, protein, and ash solution of a cancer did not produce cells but a bizarre structure characterized by the appearance of many fatty droplets.

Lipoids and proteins from a human brain produced highly organized autosynthetic cells showing active division.

#### SUMMARY OF RESEARCHES TO DATE

Cells were formed in a mixture of brain lipoid, the protein of any organ, and brain ash (electrolyte) solution.

These cells are designated autosynthetic cells.

The lipoid was extracted with ether from dried fresh brain.

The protein was extracted with salt solution from the residue remaining after the lipoid was extracted.

The brain ash (electrolyte) solution consisted of a solution in distilled water of various salts in the proportions in which they are present in the brain.

No cells preëxisted in the sterile solutions used.





# THE DIAGNOSIS AND TREATMENT OF ACUTE CRANIOCEREBRAL INJURIES

## A COLLECTIVE REVIEW\*

(PART I)

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THE number of acute craniocerebral injuries is increasing yearly, the increase being due to the use of high speed vehicles of conveyance, especially the automobile and aeroplane, and the mechanization of industry. That the automobile is becoming relatively a more frequent cause of acute craniocerebral injuries is exemplified by Vulliet's<sup>1</sup> investigations. He found that the percentage of craniocerebral injuries admitted to the hospital in the "pre-automobile era" (in the years 1896 and 1897) was 0.86, whereas the percentage of these cases admitted in recent years (in the years 1927 and 1928) was 2.5, relatively four times as

many cases. In a series of 530 cases of craniocerebral injuries reported by Crandon and Wilson,<sup>2</sup> in 1906, a fall was the

CHART I  
RELATIVE CAUSES OF CRANIOCEREBRAL INJURIES

Author	Total No.	Year	Auto- mobile (Per Cent)	Street Car (Per Cent)	Train (Per Cent)	Falls (Per Cent)	Blows (Per Cent)	Gun- shot (Per Cent)	Un- known (Per Cent)	Miscel- laneous (Per Cent)
Crandon and Wilson	530	1906				80				
Besley	1000	1916				38.4	31.1	3.8	26.7	
Lecount and Apfelbach	504	1920	8.8	11.4		23.8	9.4		29.6	3.3 Chiro- practors
Stewart	6135	1921	23.8 Motor- cycle 3.5	9.4	3.2	33.8	21.8	1.6		1.3
Connors	336	1927	34.2	6.5		30.3	8		14.5	3.6
Vance*	512	1927	36.8	3.8		29.8	8.9		19.5	
McCreery and Berry	520	1928	21.1	2.6		34.6	11.9		26.9	
McClure and Crawford	441	1928	54.2	2.3	2	20	18.4	4		3.4

\* Autopsy Series.

speed vehicles of conveyance, especially the automobile and aeroplane, and the mechanization of industry. That the automobile is becoming relatively a more frequent cause of acute craniocerebral injuries is exemplified by Vulliet's<sup>1</sup> investigations. He found that the percentage of craniocerebral injuries admitted to the hospital in the "pre-automobile era" (in the years 1896 and 1897) was 0.86, whereas the percentage of these cases admitted in recent years (in the years 1927 and 1928) was 2.5, relatively four times as

etiologically factor in 80 per cent, whereas in McClure and Crawford's<sup>3</sup> more recent series of cases the automobile was responsible for 54.2 per cent of the injuries, and falls and blows were the cause in 20 and 18.4 per cent, respectively (Chart I).

The present-day conception of craniocerebral injuries differs considerably from that held prior to the last two decades. Prior to this time more attention was paid to the injury of the cranium, which injury was considered more important than the injury to the brain, which is contained

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within the cranium. Even though at the present time the degree of cerebral injury is considered the all important factor in craniocerebral injury by most physicians, there is still the tendency among laymen and insurance companies and unfortunately among certain practitioners to place more stress on injury of the rigid skull than injury of the delicate cranial contents, the brain. Trotter,<sup>4</sup> in discussing the evolution of head injuries, states that our knowledge of head injuries may be divided into three developmental stages. (1) The early period, which lasted up to the last third of the nineteenth century, was characterized by injuries of the skull dominating the subject of head injuries. (2) The middle period, that which extended from the last third of the nineteenth century up until about the beginning of the present century, was characterized by the experimental physiological advances made by the study of intracranial physiology. As the result of the researches of Horsley, Hill, Kocher, and Cushing, the importance of the venous side of the circulation as regards cerebral symptoms was emphasized. (3) The modern period dates from the beginning of the present century and is characterized by the realization that variable degrees of injury of the cerebrum may occur and that the cerebral injury is responsible for the symptoms. The degrees of injury are variations in the degrees of contusion of the brain substance. That lesions of the skull are of relatively little importance in acute craniocerebral injuries has been emphasized by Newell,<sup>5</sup> Trotter,<sup>4</sup> Arnaud and Albert-Crémieux,<sup>6</sup> McClure and Crawford,<sup>3</sup> Vance,<sup>7</sup> Green,<sup>8</sup> Holbrook,<sup>9</sup> and Symonds.<sup>10</sup> Fay<sup>11</sup> states, "Fractures of the skull are rarely, if ever, the cause of death, although it is conceivable that a spicule of bone may be driven into the medulla and thus terminate the patient's life. The vast majority of cases that die from head injuries succumb to intracranial pressure or hemorrhage." This differentiation may appear didactic because as a rule an injury which is severe

enough to cause a fracture of the cranium will also produce cerebral damage. The symptoms, however, in such a case are due to the cerebral injury, and it is the injury to the cerebrum and not to the cranium (except in depressed fractures) which requires treatment. On the other hand, simple fractures of the skull do occur in which there is no associated cerebral injury and vice versa, extensive cerebral injuries may be present without any concomitant lesions of the cranium. In a series of autopsies reported by Vance<sup>7</sup> with special reference to fracture of the skull, brain lacerations were found even though a fracture of the skull was not present. In Vance's<sup>7</sup> series of cases these were invariably produced by contrecoup violence, usually resulting from a fall. In a series of 441 cases of craniocerebral injuries reported by McClure and Crawford,<sup>3</sup> 172, or 39 per cent, were unassociated with skull fracture.

In reported series of cases there is considerable variation in the age incidence of craniocerebral injuries. McClure and Crawford<sup>3</sup> found the average age in their series to be thirty years. In Connors'<sup>12</sup> Stewart's,<sup>13</sup> and Vance's<sup>7</sup> series of cranial fracture, the age incidence varied considerably. In Vance's<sup>7</sup> series of 507 cases, the greatest number (22+ per cent) in any one decade was between the ages of forty and fifty years. Stewart<sup>13</sup> in his series of cases found that the average age was thirty-six, whereas Connors<sup>12</sup> found the greatest number (22+ per cent) occurred between one and ten years. There is no apparent reason why such a great discrepancy concerning the age incidence should exist.

#### CLASSIFICATION OF CRANIOCEREBRAL INJURIES

1. Those with cerebral injury either associated with or without cranial injury.
  1. Concussion
  2. Edema
  3. Contusion
  4. Laceration
  5. Hemorrhage

- a. Intradural
- b. Extradural
11. Those without brain involvement.
  1. Scalp wounds
  2. Skull fracture
    - a. Vault
    - b. Base
    - c. Simple
      1. Linear
      2. Comminuted
    - d. Depressed
    - e. Compound

#### I. CEREBRAL INJURY WITH OR WITHOUT CRANIAL INJURY

##### 1. Concussion

There is considerable controversy at the present time among physiologists, clinicians, and pathologists concerning the use of the term concussion. The controversy has arisen largely because of the indefiniteness of the term. If it is kept in mind that concussion is a clinical syndrome which is based upon no pathologic findings, but upon definite clinical symptoms and signs together with a typical clinical course, its use seems justifiable. Concussion is in reality a physiologic and not an anatomic lesion in that no changes can be demonstrated in the cerebrum. Miller<sup>14</sup> defines concussion as a condition which is characterized by "a group of symptoms which are the result of a temporary inhibition of cortical function with or without stimulation or inhibition of one or more of the medullary centers, but which are not accompanied by pathologic lesions." A number of theories have been advanced to explain the condition, concussion. Duret,<sup>15</sup> Heise<sup>16</sup> and Symonds<sup>10</sup> believe that a generalized cerebral anemia is responsible for the clinical symptoms. Tilmann<sup>17</sup> is of the opinion that as a result of the tearing apart of the gray and white matter there occurs a difference in their specific gravities. The fact that a rapid recovery occurs in most cases of concussion, however, does not support this theory. Rahm<sup>11</sup> believes that as a result of the blow there is a new arrange-

ment of the lipoids, protein molecules, and electrolytes in the cerebral cells. Knauer and Enderlen<sup>19</sup> found experimentally that following a severe blow a rapid acidification of the cerebral cortex occurred. Relatively recently Vara-Lopez<sup>20</sup> demonstrated that in experimentally produced concussion there was a decrease in the hydrogen ion concentration of the spinal fluid, occurring within two minutes after the trauma. In each instance the hydrogen ion concentration had returned to normal after twenty-four hours. Henschen<sup>21</sup> believes that concussion is produced by interference with or interruption at the synaptic junctions of the subcortical centers within the midbrain. These theories are merely speculative and at the present time no proof has been offered concerning the exact cause of the symptoms which are present in concussion. Miller<sup>14</sup> attempted to produce concussion experimentally in animals by single severe or repeated light blows or by the application of an electric current to the medulla. He found that early in the stage of what he considered was concussion in animals there was a stimulation of the medullary centers, especially an increase in respiratory rate and a rise in blood pressure. As the concussion increased, the medullary centers became inhibited and depressed, resulting in an inhibition or paralysis of the respiratory center. Miller<sup>14</sup> was able to demonstrate quite definitely that cerebral anemia was not the cause of concussion. When death did occur, it was due to paralysis of the respiratory center, but as it was temporary, life could be maintained by artificial respiration. He believes that the condition is due to a molecular disturbance of the cell as no gross lesion was demonstrable microscopically. Jackson<sup>22</sup> found experimentally that pressure on the medulla produced the following phenomena: first, an increase in respiration, a slight rise in blood pressure accompanied by a normal pulse rate, and, later, a decrease in respiration, a fall in blood pressure, and a marked slowing of the heart rate.

Concussion is characterized by immedi-

ate and temporary unconsciousness, usually followed by headache, nausea, and occasionally vomiting. Characteristically, there is a rapid recovery from all symptoms. Whereas most patients with concussion recover, it infrequently occurs that patients die without recovering consciousness and in whom at necropsy no gross lesions can be demonstrated. Supposedly these individuals die from concussion. In McClure and Crawford's<sup>3</sup> cases there were 351 cases of concussion, 257 of which were associated with skull fractures and 94 associated with no lesion in the cranium. In a series of 507 autopsies reported by Vance,<sup>7</sup> death from cerebral concussion occurred in 139, or 27.4 per cent; 86 died within a few minutes; 34 in from one to four hours; 11 in from five to ten hours; and in 8 the duration was unknown. Ritter and Strebel<sup>23</sup> are of the opinion that a concussion of the medulla oblongata occurs more frequently and is more important than concussion of the cerebrum. In an analysis of 349 cases admitted to the Zurich Surgical Clinic from 1919 to 1924, 95 cases (27.22 per cent of the entire number of cases, or 83.3 per cent of the true concussions) showed evidence of involvement of the medulla oblongata. Ritter and Strebel<sup>23</sup> believe that concussion of the medulla is evidenced by respiratory and circulatory disturbances, vomiting, blood pressure changes, and unconsciousness. In all cases there was immediate unconsciousness, which in the majority of cases lasted only a few minutes, and never lasted more than five hours. In the majority of cases a retrograde amnesia, present in 63.1 per cent, was associated with unconsciousness. There was an increased pulse rate in 57.9 per cent. Differentiating points between concussion of the medulla oblongata and that of the cerebrum are: in the former the manifestations are more varied, the symptoms appear more slowly, and sequelae occur more frequently. The amount of trauma necessary to produce a concussion of the cerebrum seems to be greater than that

which would produce a concussion of the medulla oblongata. Jackson<sup>22</sup> demonstrated experimentally that pressure over the medulla produced definite symptoms (first, stimulation in respiration and rise in blood pressure; later, decrease in respiration, fall in blood pressure and slowing of pulse rate), whereas pressure over the temporal and parietal regions of the brain produced no change in respiration, blood pressure, or pulse rate.

Concussion of the cerebrum occurred in only 4.29 per cent of the entire number of Ritter and Strebel's<sup>23</sup> cases (13.19 per cent of the cases of concussion). Unconsciousness did not develop as frequently as in concussion of the medulla. It was absent in 20 per cent of the cases. In 80 per cent of the cases in which it was present it occurred immediately, was deeper, and lasted definitely longer than in concussion of the medulla. It lasted more than five hours in 60 per cent of the cases. In only 20 per cent of the cases had unconsciousness disappeared within three hours. Retrograde amnesia was present in 66 per cent of the cases. Vomiting occurred in 26 per cent of the cases and the temperature was always increased. Clinically, it is particularly important to recognize a cerebral concussion in order that proper therapy may be instituted. In all individuals in whom unconsciousness has occurred irrespective of the length of time which it has persisted, a period of rest is imperative in order to prevent the development of sequelae.

## 2. *Edema*

Edema of the brain has been recognized by pathologists for a long period of time. Its significance has not been appreciated by clinicians until relatively recently; in fact, not until the introduction of the dehydration therapy, which is directed entirely against "wet brain." Le Count and Apfelbach<sup>24</sup> in a study of 504 post-mortem examinations of patients with craniocerebral injuries state that the most frequent change in the brains which they

studied of patients dying with fracture of the skull was traumatic edema. They describe the convolutions as being flat and the cerebral veins relatively empty and flat and state that the fluid in the leptomeninges is greatly diminished. Apfelbach<sup>25</sup> two years later in describing the edema of the cerebrum associated with cranio-cerebral injuries states that it characteristically is a generalized edema and not a localized one about contusions. He found that at autopsy the dura was of drum-like tensesness due to the edema, the tensesness varying with the amount of intracranial tension. The brain when removed from the cranial cavity was found to be soft and easily lost its form when laid on a flat surface. After it had been hardened for several days there was increased difficulty in cutting it, the lateral ventricles were closed, and a stippling of the brain substance by small intracerebral blood vessels was demonstrable. Microscopically, the perivascular lymph sheaths were distended and there were empty spaces between the fibers and cells, the latter being further apart than normal. Determination of the water content was made from the brains of 26 patients who died from cranio-cerebral injuries (Apfelbach<sup>25</sup>). It was found that there was an increase in the amount of water above the normal content of from 3 to 45 gm. or as high as 3.7 per cent. Edema in Apfelbach's<sup>25</sup> series of cases was found most frequently in the brains of persons who died from within several hours after the accident up to the second or third day. Green<sup>8</sup> emphasizes the importance of cerebral edema and the necessity of its prompt treatment. He states that relatively slight injury to the cranium of individuals suffering from cardio-renal disease is sufficient to produce cerebral edema. The work of Fischer<sup>26</sup> is interesting in connection with cerebral edema. Fischer<sup>26</sup> states that edema occurs whenever in the presence of water the tissue colloids are increased and that an increase in acidity causes an increase in the accumulation of colloids. The increased

acidity may be due either to increased production or insufficient elimination of acids. Henschen<sup>21</sup> has found that in patients recovering from concussion and contusion of the brain there is an increased secretion of lactic acid, acetic acid, and phosphoric acid in the urine. Vara-Lopez<sup>20</sup> has found a decrease in hydrogen ion concentration of the cerebrospinal fluid in concussion. Knauer and Enderlen<sup>19</sup> state that an acidification of the cerebral cortex occurs in cerebral concussion. It is possible that the decrease in the hydrogen ion content of the cerebrum may be responsible for the cerebral edema. That the majority of symptoms in cranio-cerebral injury are the result of increased intracranial pressure is accepted by most authorities today. This increase in intracranial pressure is in by far the majority of cases the result of cerebral edema, which in a relatively short time produces a vicious circle; i.e., as the result of the increased intracranial pressure there is interference with the venous return which hinders absorption of the cerebrospinal fluid. This results in actual increase in the amount of cerebrospinal fluid. As the condition progresses, the arterioles become compressed, producing a cerebral anemia.

### 3. Contusion of the Brain

Contusion of the brain frequently follows trauma to the head. Le Count and Apfelbach<sup>24</sup> in their study of 564 brains of patients dying with skull fractures found that contusion of the cerebrum, when present, was usually wedge-shaped and that the brain was infiltrated with blood for a depth of from 2 to 4 cm. over an area with an outside diameter of from 4 to 5 cm. This type of contusion was found in 49.2 per cent of their series, in 73.3 per cent of which it was due to a contrecoup injury. Similar areas of localized contusions are reported by Arnaud and Albert-Crémieux.<sup>6</sup> Cerebral contusions occurred in only 7.03 per cent of McClure and Crawford's<sup>3</sup> cases, which, however, were observed clinically and not at necropsy. Contusion

is of importance, because it is frequently the cause of death. According to Vulliet,<sup>1</sup> massive cerebral contusion was the cause of death in 18.7 per cent of 96 cases observed by him, whereas Trotter<sup>4</sup> is of the opinion that contusion of the brain is probably the most common cause of death and that most of the symptoms produced by cerebral injury are the result of contusion. Symonds<sup>27</sup> differentiates between a major and a minor type of contusion, the difference being one of degree. He considers clouding of the consciousness or stupor as a distinguishing feature of major contusions. The patient does not recover, but remains stuporous, restless, and irritable. Patients with minor contusion complain, however, of headaches, giddiness, and mental disability. In contrast to concussion the symptoms of contusion usually develop after a latent period of hours or days. The headache is dependent upon changes in posture. Stupor, according to Symonds, is not a prominent part of minor contusion. Contusion is associated pathologically with varying degrees of hemorrhage, varying from small petechiae to rather extensive effusion. Apfelbach<sup>25</sup> has shown that characteristically the hemorrhage associated with contusion is greater, within certain limits, the longer the patient lives after the injury. The brain of an individual who died shortly after the injury shows evidence of contusion which is superficial, whereas if life is continued for from one to two days, larger contusions are found. This Apfelbach<sup>25</sup> believes might be due to the persistence of the bleeding after the injury has ceased.

#### 4. Lacerations

Laceration of the cerebrum represents a more extensive injury than contusion. Even though its differentiation from contusion may be an artificial one, the difference being largely of degree, it is, however, deemed advisable to consider lacerations separately, especially in those cases in which there is definite tearing of the cerebral substance as contrasted with the

bruising which occurs in contusion. According to Bland<sup>28</sup> laceration is usually associated with or dependent upon fracture of the skull. In McClure and Crawford's<sup>3</sup> series of 441 cases of craniocerebral injuries treated at the Henry Ford Hospital there were 54 with laceration of the cerebrum, 5 without skull fracture, and 49 associated with fracture. In addition, there were 5 cases of laceration and hemorrhage, all associated with skull fracture. In 504 necropsy examinations of patients with skull fracture reported by Le Count and Apfelbach,<sup>24</sup> severe laceration of the brain measuring 40 cm. in diameter and extending into the brain substance for from 4 to 5 cm. was found in 64 instances (slightly over 10 per cent). In 15 of these the lacerations extended into one of the lateral ventricles. In 39 bleeding continued intracerebrally for several centimeters beyond the laceration. Thirty-six of the lacerations occurred in the frontal lobe, 3 in the occipital lobe, and all except 8 were contrecoup injuries. Bagley,<sup>29</sup> on the other hand, believes that lacerations of the cortex are the result of direct force of the blow and may be associated with simple or compound fractures of the skull, but frequently occur without fracture of the skull. The tips of the temporal and bases of the frontal lobes were most often the seats of laceration in Bagley's<sup>29</sup> experience. Vance<sup>7</sup> classifies cerebral lacerations associated with skull fractures into direct lacerations and contrecoup lacerations, of which the contrecoup variety occurs more frequently than the direct. In his series of 512 necropsies of individuals with fracture of the skull, 24 died of cerebral lacerations. Of this number 6 had unilateral, whereas 11 had bilateral contrecoup lacerations; 4 had direct lacerations and 3 direct and contrecoup lacerations. In Le Count and Apfelbach's<sup>24</sup> and Vance's<sup>7</sup> series contrecoup laceration occurred as a rule when the skull as a moving object struck against a fixed object. This is explained by Le Count and Apfelbach<sup>24</sup> by the fact that during the movement of the head the brain lags

behind the more rapidly moving cranium and at the moment of the impact the brain is closer to the cranium opposite to the point where the violence is applied.

### 5. Hemorrhage

Hemorrhage associated with craniocerebral injuries is of two types, intradural and extradural. Associated with every cerebral injury from the slightest contusion to the more extensive laceration, there are varying degrees of hemorrhage. (a) *Intradural* hemorrhage occurs as a result of cerebral contusion or laceration, whereas extradural hemorrhage occurs as a result of injury to the middle meningeal artery, one of its branches, or rarely the lateral venous sinus. Due to the work of Kocher,<sup>30</sup> the clinical significance of extradural hemorrhage has probably been overemphasized. By this I do not mean that the presence of an extradural hemorrhage is not important, but because localized hemorrhage is so amenable to surgical therapy the relative importance of this type of intracranial lesion probably has been overemphasized by surgeons. Localized hemorrhages occur much less frequently than do the other types of lesions previously discussed. In 96 cases of craniocerebral injury reported by Vulliet<sup>1</sup> a localized hematoma occurred in only 2 instances. Massive hemorrhage associated with cerebral lacerations occurred in only 5 of McClure and Crawford's<sup>3</sup> 441 cases of craniocerebral injuries. Apfelbach<sup>23</sup> states that hemorrhage may occur at the junction of the gray and white matter of the cerebral substance without any gross evidence on the surface of the brain opposite the point of hemorrhage. The hemorrhage may extend from here out toward the periphery. In Vance's<sup>7</sup> 512 necropsies, 312 deaths were caused by subdural hemorrhage, the majority of the patients dying within twenty-four hours. Fractures associated with the subdural hemorrhage occurred most often in the posterior and lateral portions of the skull. In the 132 cases hemorrhage was produced by contrecoup lacerations in 85,

by direct laceration in 21, and by contrecoup and direct laceration combined in 21 cases. Vance<sup>7</sup> considered a case of having subdural hemorrhage whenever there was enough hemorrhage to produce compression of the brain. The average weight of the subdural coagulum was 6.1 gm. In 100 per cent, 73.8 per cent, and 84 per cent of fractures of the anterior, middle, and posterior fossas, respectively, in Le Count and Apfelbach's<sup>24</sup> series of cases a subdural hemorrhage was found. According to Jackson<sup>22</sup> 20 per cent of the cases of craniocerebral injury which come to autopsy have a middle meningeal hemorrhage with increased cerebrospinal pressure. One hundred and fifteen instances of subdural hemorrhage occurred in fracture of the posterior fossa examined by Vance, or 84.5 per cent. In 98 cases there was an associated subdural hemorrhage in fractures of the middle fossa, or 73.8 per cent, whereas subdural hemorrhage occurred in 100 per cent of the cases of frontal fossa fractures. The importance of subdural hemorrhage and the presence of blood in the spinal fluid has been emphasized by Essick<sup>31</sup> and Bagley,<sup>32</sup> both from a clinical and experimental viewpoint. Essick<sup>31</sup> found experimentally that the injection of laked blood into the subarachnoid space produced a sterile meningitis. Experimentally, Bagley<sup>32</sup> injected blood into the subarachnoid space of 18 adult dogs and 26 puppies. Spasticity occurred immediately after the injection. Many of the dogs died within the first few days. The diminished activity and the poor development of the younger dogs were characteristic. Microscopically, following the introduction of blood into the cerebrospinal fluid there was definite evidence of reaction of the meninges coming in contact with the blood. Subsequently changes in the cortex occurred, and in young puppies moderate dilatation of the ventricle followed. In 6 of the 19 puppies which received injections and in which autopsies were performed, a definite dilatation of the ventricles was found. Subdural hemorrhages are of importance not only



because of the immediate symptoms which may be produced, but because of subsequent lesions. Fay and Winkelman<sup>33,34</sup> have emphasized the importance of diffuse collections of cerebrospinal fluid over the cerebral cortex following subdural hemorrhage with resulting cerebral atrophy as the result of pressure. In addition to the diffuse types of subdural fluid collections following subdural hemorrhage, there are localized lesions first described by Virchow,<sup>35</sup> but not appreciated clinically until recently. These consist of cystic changes in localized hematomas. Valuable contributions to the question of subdural hematoma or chronic hemorrhagic pachymeningitis have been made by Naffziger,<sup>36</sup> Grant,<sup>37</sup> Rand,<sup>38</sup> and Cohen and Elsberg.<sup>39</sup>

(b) *Extradural Hemorrhage*: Extradural hemorrhage is of less importance than subdural hemorrhage in so far as it occurs much less frequently. However, because of the marked increase in intracranial pressure which is produced by an extradural hemorrhage and because of the fact that it is especially amenable to surgical treatment, it is important, from the standpoint of treatment that the possibility of an extradural hematoma should always be considered. The hemorrhage usually occurs from the middle meningeal artery or one of its branches. In most cases the anterior branch of the vessel is the portion most frequently injured, either because of tearing of the vessel by fracture or tearing of the vessel by detachment of the dura from the inside of the cranium. Extradural hemorrhage occurred in 39.4 per cent of the necropsy series reported by Le Count and Apfelbach.<sup>24</sup> In only 52.2 per cent of this group, however, was the hemorrhage large enough to produce an appreciable compression of the brain. Of the large extradural hemorrhages 70.1 per cent were associated with fracture of the middle fossa, 14.4 per cent were associated with those of the posterior fossa, and 9.6 per cent were associated with fractures of the vault, 2.8 per cent with fracture of the anterior fossa. In a series

of 507 cases observed at necropsy and reported by Vance,<sup>7</sup> extradural hemorrhage was described in 106. Only 61 (12 per cent of the latter) of these, however, were large enough to prove fatal by cerebral compression. In a series of 233 cases in which a fracture was present in the lateral part of the skull in only 56 (24 per cent) was the middle meningeal hemorrhage sufficient to produce cerebral compression. The greatest number of extradural hemorrhages occurred in Vance's<sup>7</sup> series between thirty and forty years of age, which he believes is due to the fact that the dura is adherent just enough to the skull to allow laceration of the artery, but not adherent enough to prevent its separation from the bone. The extradural hemorrhage in Vance's<sup>7</sup> series of 61 cases originated in the posterior branch of the middle meningeal artery in 25, in the anterior branch in 12, in the main stem in 4, in a branch of the middle meningeal which was not determined in 15, in the anterior meningeal artery in 1, and in the lateral venous sinus in 4.

## II. INJURIES NOT INVOLVING THE BRAIN

### 1. Scalp Wounds

The importance of scalp wounds in acute craniocerebral injuries has not been sufficiently appreciated by the medical profession. Weaver<sup>40</sup> emphasizes the proper care of scalp wounds and considers them as potential brain abscesses, as they are frequently the sites through which organisms can gain entrance to the cerebrum. Of 520 cases of cranial fracture reported by McCreery and Berry,<sup>41</sup> in 216 there was an associated scalp wound, 37 of which communicated with the fracture. Sixty per cent of 6117 cases of skull fracture reported by Stewart<sup>13</sup> were associated with lacerations of the scalp, 98 of which occurred in the frontal region, 130 in the parietal, 88 in the occipital, and 55 per cent in the temporal area.

### 2. Fractures of the Skull

There is considerable variance among authors concerning the relative frequency



of fractures of the vault. In general, however, it might be said that statistics based upon necropsy investigations show a relatively low percentage of skull fractures involving the vault. In Vance's<sup>7</sup> series of 512 cases, the vault alone was involved in only 6.7 per cent, whereas the vault and base were involved in 91.9 per cent. In Le Count and Apfelbach's<sup>24</sup> series the vault was involved in 9.9 per cent and the base in 89.8 per cent. In clinical series, however, vault fractures occur more frequently than basal fractures, probably because basal fractures are not diagnosed because of the difficulty in demonstrating them roentgenologically. In McClure and Crawford's<sup>3</sup> clinical series of 441 cases, 85.7 per cent of the cases of fracture were fractures of the vault and only 5.7 per cent were fractures of the base alone. Stewart<sup>13</sup> states that 70 per cent of the linear fractures of the vault extend to the base by the shortest route. Vance<sup>7</sup> explains the higher percentage of basal fractures as compared with those of the vault on anatomical grounds. The vault is stronger and with the exception of the temporal region is of even thickness. The base, however, is of irregular, flat construction, composed of heavy masses of bone weakened by thin plates. He<sup>7</sup> believes, as does Stewart,<sup>13</sup> that in most instances fractures begin in the vault and extend down to the base. The fissures course along between the strong masses of bone and are directed toward the central part of the skull. According to Peet<sup>42</sup> fractures of the vault are the result of localized trauma.

Basal fractures are frequently overlooked, because of the difficulty in diagnosing the condition, largely because of inconstant and indefinite radiographic signs. As evidenced by necropsy examinations of Vance,<sup>7</sup> Le Count and Apfelbach,<sup>24</sup> basal fractures either alone or associated with fractures of the vault are the most frequent type of fracture of the skull. In Vance's<sup>7</sup> series of cases the posterior fossa was involved in 34.8 per cent, the middle fossa in 45.2 per cent, and the

anterior fossa in 11.9 per cent of the cases. In Le Count and Apfelbach's<sup>24</sup> series the anterior, middle, and posterior fossae were involved in 12.1 per cent, 32.9 per cent, and 35.3 per cent of the cases, respectively. Because basal fractures are apt to extend either into the nose, nasal accessory sinuses, or the middle ear, the danger of the occurrence of secondary infection of the meninges is especially great. Prognosis should be more guarded in basal fractures not only because of the danger of infection, but also because of associated injury to the cortical centers. Peet<sup>42</sup> believes that fractures of the base are the result of a massive blow, usually much more severe than that responsible for fractures of the vault and are associated with more extensive cerebral injury. Of 39 fractures of the vault reported by Blahd<sup>28</sup> there was a mortality of 13 per cent, whereas in 20 cases of fracture of the base there was a mortality of 65 per cent.

Of the various types of fractures, simple fractures occur most frequently. A simple fracture may produce no symptoms and be of no clinical significance; in fact, the only significant feature about a simple fracture of the skull is an associated cerebral injury. Compound fractures, however, are of definite significance because of the danger of the introduction of microorganisms into the wound and the subsequent infection. The proper care of compound fractures has been stressed by Cushing<sup>43</sup> and others.<sup>44,12</sup> Of 37 operations performed by Thorning<sup>45</sup> in a series of 100 cases of acute craniocerebral injury, 51 per cent were performed for compound fractures. Compound fractures are, therefore, of surgical interest. Depressed fractures are also distinctly surgical and require operative intervention. The fragment because of its direct pressure on the cerebral cortex may give rise to very definite symptoms. Bagley<sup>29</sup> is of the opinion, however, that if the dura remains intact that the depression may be of little significance. Depression occurred in 198 of the 408 fractures of the vault reported by Stewart<sup>13</sup> and

in only 5.1 per cent of 520 cases reported by McCreery and Berry.<sup>41</sup>

#### DIAGNOSIS

The diagnosis of acute craniocerebral injuries is extremely important. A great deal can be learned from the history. Of paramount importance is the presence or absence of consciousness, as extensive cerebral injury is always associated with unconsciousness. McClure and Crawford<sup>3</sup> believe that the degree and the duration of the primary unconsciousness serve as a fair index to the severity of the injury and probable subsequent course, except in hemorrhage and infection. One of the diagnostic features of concussion is immediate unconsciousness which is invariably present. In McCreery and Berry's<sup>41</sup> 520 cases of skull fracture, 178 were conscious and rational, 23 were stuporous, and 218 were in coma on admission to the hospital. The clinical syndrome, as described by Kocher,<sup>30</sup> of temporary primary unconsciousness followed by a lucid interval later followed by unconsciousness, is characteristic of a rapidly increasing intracranial pressure of a severe degree which is almost invariably associated with intracranial hemorrhage, usually from the middle meningeal artery. These cases, however, are relatively rare as compared with the large number of acute craniocerebral injuries.

The pulse rate has been considered of diagnostic value in acute craniocerebral injuries. Newell places it second to the history. It is now known that too much dependence should not be placed on the pulse rate as there may be little alteration in the pulse early in the condition, changes in pulse rate being the result of considerable cerebral damage and indicating an advanced lesion. It is probably of more value as a prognostic agent than as a diagnostic agent. Fay<sup>11</sup> attached considerable significance to the pulse rate and also the character of the pulse. He believes that a pulse rate of 70 or below is the result of a vagus irritation and the cause should be ascertained. As possible causes one must

consider bloody spinal fluid, increased intracranial pressure, edema of the cardiac center, or middle meningeal hemorrhage. In Ritter and Strebel's<sup>23</sup> series of 349 cases of concussion of the medulla oblongata, the pulse rate was slightly increased in 57.9 per cent and normal in 40 per cent. Jackson<sup>22</sup> found experimentally that pressure over the medulla produced at first little change in the pulse rate; later, however, the heart rate became slowed. The pulse rates of patients with acute craniocerebral injuries, when admitted to the hospital, may vary considerably. This becomes self-evident when it is kept in mind that many patients with acute craniocerebral injuries are in shock when admitted. Characteristically the pulse in shock is of a small volume, and the rate is usually increased which is dependent upon the condition of shock and not dependent upon the cerebral injury. The thready pulse which these patients have is the result of lack of resistance in the capillary bed. According to Fay<sup>11</sup> this phenomenon is of extreme importance in that the anoxemia associated with lowered vascular tension predisposes to further edema, because of the increased permeability of the capillaries as shown by Landis.<sup>46</sup> In cases with marked increase in intracranial pressure as seen in hemorrhage from the middle meningeal artery, the pulse becomes definitely slowed due to edema of the medullary centers. This, however, represents an advanced lesion and is always associated with a marked increase in intracranial pressure. Associated with the bradycardia is a definite rise in the blood pressure and unconsciousness. This symptom complex should never be waited for, but the diagnosis of increased intracranial pressure should be made before these symptoms present themselves. In 39 of McCreery and Berry's<sup>41</sup> 520 cases the pulse on admission was less than 60. Twenty-nine of these patients died.

Miller<sup>11</sup> believes from his experimental work that the determination of respiratory rate is of great deal of significance in

cerebral concussion. He was able to demonstrate experimentally that of all the medullary centers the respiratory center was affected earliest by cerebral injury. In less extensive injuries there resulted a stimulation of the respiratory center with an increase in respiratory rate as well as an increase in amplitude. As the injury became more severe, there resulted a paralysis of the respiratory center with cessation of respiration. Jackson<sup>22</sup> found experimentally that pressure over the medulla produced increase in respiration, which was later followed by a decrease. Miller<sup>14</sup> believes that this respiratory paralysis is responsible for the sudden death in concussion. Newell<sup>5</sup> states that as the intracranial pressure becomes increased, respirations become labored and slowed. Fay<sup>11</sup> considers the respiratory rate of extreme importance, especially as regards prognosis. If it is above 26, it frequently indicates cerebral irritation and blood is usually found in the spinal fluid. If the respiratory rates reach 40 per minute, there is indication of severe cerebral damage. The hyperpnea is of importance because of the hyperventilation with the subsequent washing out of the carbon dioxide and the development of alkalosis and edema. Decreasing respiratory rates, according to Fay,<sup>11</sup> are usually the result of increased intracranial tension. In contrast to the experimental results of Miller<sup>14</sup> and Jackson<sup>22</sup> are the clinical findings of Besley,<sup>47</sup> who in an analysis of 1000 cases of skull fracture admitted to the Cook County Hospital in Chicago, found the following: Patients who recovered with fractures of the vault had an average respiratory rate of 24 and those who died had an average rate of 32. Patients who recovered with basal fractures had an average respiratory rate of 24, whereas those who died had an average rate of 40.

Of primary importance as far as diagnosis is concerned Newell<sup>5</sup> believes is the temperature. He states that it is usually subnormal immediately after brain injury, but in mild cases after twenty-four hours

it rises to from 99.4 to 100.4°F. It is not clear from his publication whether those cases with decreased temperature were associated with shock or not. Undoubtedly many cases were associated with shock and in all probability the shock was the cause of the decreased temperature rather than the cerebral injury. Symonds<sup>27</sup> is of the opinion also that early in cerebral injuries the temperature is decreased. In Besley's<sup>47</sup> series of 1000 cases of skull fracture the average temperature of those patients who recovered was 100°F., whereas that of those who died was 102°F. In the series with concussion of the medulla oblongata reported by Ritter and Strebel,<sup>23</sup> the temperature on the first day was below 37°C. in 49.4 per cent, from 37 to 38°C. in 21.05 per cent, from 38 to 39°C. in 3 per cent of the cases.

Careful physical examination of the entire body, provided that the patient is not in extreme shock, will yield considerable information concerning the nature and extent of the cerebral injury. In such examination special care should be paid to the ears, nose, and mouth in order to determine whether there is evidence of escaping blood or spinal fluid. Hemorrhage from these natural orifices, unless there is an obvious wound from which bleeding may occur, is indicative of basal skull fracture. Ecchymosis may occur around the eyes or behind the ear, or over the mastoid process (Battle's sign). The prognosis is much worse in those cases in which there is hemorrhage from the ears, nose, or mouth, because of the possibility of organisms gaining entrance to the meninges as a result of the compound fracture. Schuster<sup>48</sup> states that middle ear fractures have a poor prognosis, because this portion of the temporal bone does not heal well, which may result in a permanent communication between the middle ear and the meninges. According to Davis,<sup>49</sup> hemorrhage from both ears is an especially unfavorable sign, the mortality rate in his series being 66 per cent and 39 per cent in cases with bilateral and unilateral hemorrhage, respec-

tively. The danger of meningitis is especially great in cases in which there existed previously an infection of the middle ear, mastoid process, or nasal accessory sinuses. In addition to hemorrhage and discharge of cerebrospinal fluid from the ear, Schuster<sup>48</sup> states that in about 40 per cent of all head injuries there are other symptoms referable to the ear; i.e., impaired hearing, dizziness, and tinnitus. These were the most frequent sequelae in McCreery and Berry's<sup>41</sup> cases, but there was a definite tendency for improvement to take place within eighteen months to two years. The symptoms which persisted after that period of time appeared to be permanent. In Davis's<sup>49</sup> cases of head injury in which there was an associated eighth nerve paralysis, the paralysis was immediate in all cases, and all patients recovered even after long intervals.

A careful neurological physical examination is extremely important and should be repeated frequently in order to detect any progression of the various lesions. In McClure and Crawford's<sup>3</sup> and McCreery and Berry's<sup>41</sup> series of cases the seventh and eighth nerves were more frequently involved than any of the other cranial nerves. Fay<sup>11</sup> considers aphasia as an important localizing sign. Care must be taken not to confuse it with stupor. They can be differentiated by reaction of the patient to an extremely painful stimulus. If the patient is aphasic, he will attempt in the normal manner to remove the stimulus, whereas if he is stuporous, his movements will be purposeless. Examinations of the reflexes, especially the Hoffman and the Babinski reflexes, are particularly valuable according to Fay.<sup>11</sup> In McCreery and Berry's<sup>41</sup> series of 520 cases of skull fracture a negative neurological examination was found in 127. Cranial nerve paralysis occurred in 58 patients, of whom 44 recovered; spinal nerve paralysis in 88 cases, of which 51 were of the flaccid type and 37 merely a weakness. Of the 51 patients with flaccid paralysis, only 3 recovered and 48 died. Of the 37 in whom muscular weakness was

demonstrated, 14 recovered and 23 died. The superficial reflexes were decreased in 58; the deep reflexes were decreased in 63 and increased in 79. Abnormal reflexes were present in 62.

Of extreme importance as regards the extent of injury, the progress and prognosis of the case, are the eye manifestations. Changes in the pupils are of great diagnostic and prognostic significance. According to Lyerly<sup>50</sup> the size of the pupil normally seldom varies in the two eyes. Barric<sup>51</sup> found on examination of 326 recruits with apparently normal eyes an inequality of the pupils in about 10 per cent. Characteristic of pupillary changes in acute cerebral injury are the inconstant findings on repeated and frequent examinations. According to Blakeslee<sup>52</sup> the pupillary changes, which are the most frequent of all eye manifestations, may change in such a way that one or both pupils might assume a different size or shape or become eccentric within a period of a few hours. McClure and Crawford<sup>3</sup> recommend repeated eye examinations, because of the frequent changes which are apt to and do occur in severe acute cranioerebral injuries. The importance of careful examination of the eyes in head injuries is exemplified by Blakeslee's<sup>52</sup> study. In a series of 610 cases of cranial fracture, 475 (78 per cent) manifested eye signs, whereas only 133 (22 per cent) had normal eye findings. Pupillary changes were observed in 378 patients and of this number 179 (47.5 per cent) died. In his series of cases he was able to divide the pupillary phenomena into eight groups: (1) widely dilated pupils with fixation; (2) widely dilated pupils with preserved reaction to light, (3) unilateral and fixed pupils; (4) pupils equal in size and not markedly dilated or contracted; (5) pupils unequal in size and not markedly dilated or contracted; (6) pupils contracted and fixed; (7) pupils contracted with preserved reaction to light; (8) pupils usually dilated with or without light reflex or a dilated pupil with partial ptosis or slight divergent strabismus, associated

with a contralateral upper motor neuron paralysis (partial Weber's syndrome). Macewen,<sup>53</sup> in 1887, stated that unilateral dilatation and fixation of the pupil were associated with fracture of the middle fossa of the skull, and in those cases in which necropsies were obtained, the basal fracture continued into or toward the vertex, and a massive clot in most instances occupied the whole of the middle fossa extending from the petrous portion of the temporal bone to the vertex. In McClure and Crawford's<sup>3</sup> series of cases the pupil was usually dilated on the side of the lesion, and in all patients with dilated and fixed pupils a fatality resulted. Blakeslee<sup>52</sup> states that even though it is generally agreed that a unilaterally dilated and fixed pupil is a localizing sign of epidural hemorrhage, appearing on the side of the hemorrhage and fracture, it may occur in cases with epidural and subdural hemorrhage on the homolateral side, and not infrequently is seen in contrecoup laceration and hemorrhage. Holman and Scott<sup>51</sup> state that a unilateral dilatation and fixation of the pupils almost invariably occur on the side of the lesion and are usually the result of progressively increasing cerebral compression from hemorrhage. McCreery and Berry<sup>41</sup> found in their series that a unilateral enlargement and fixation of the pupil were indicative of a lesion on the homolateral side.

Eye manifestations in cerebral injuries are extremely important as regards prognosis. Of 610 cases of fracture of the skull observed by Blakeslee,<sup>52</sup> 78 per cent showed eye signs, of which number 79.5 per cent consisted of pupillary changes. Forty-seven and five-tenths per cent of the patients with pupillary changes died. In a series of 75 cases of skull fracture in which death occurred in 24, Cohen<sup>55</sup> found the following pupillary changes: in the 24 fatal cases the pupillary findings were normal in 6 and abnormal in 18, whereas in the 51 non-fatal cases the pupillary findings were normal in 21, abnormal in 4, and in 3 the findings were not stated. In McCreery

and Berry's<sup>41</sup> series of 520 cases of cranial fracture the pupils were normal in 284 of which number 231 recovered and 53 died. There were pupillary changes in 231 patients of whom 151 recovered and 80 died. Of Stewart's<sup>13</sup> 617 cases of skull fracture, the pupils were normal in 396 and the pupillary findings were abnormal in 221. Of the patients in Blakeslee's<sup>52</sup> series with widely dilated and fixed pupils 94.5 per cent died. All the patients in Stewart's<sup>13</sup> and McClure and Crawford's<sup>3</sup> series who had widely dilated and fixed pupils died. All those in Stewart's<sup>13</sup> series presenting these phenomena died within five minutes to two hours after admission to the hospital. Walton<sup>56</sup> found a fixation of the pupil in 39 of his 53 fatal cases. Nicols<sup>57</sup> states that fixation of the pupils is a much more serious omen than is inequality of the pupils. Of 54 patients having skull fracture in whom there was a fixation of the pupils, 47 died. Cohen<sup>55</sup> and Gunn<sup>58</sup> state that inequality combined with fixation of the pupils is common in fatal cases of head injury, whereas these signs are found infrequently in those patients who recover. Unilateral dilatation with fixation of the pupil is a less serious sign than is bilateral fixation and dilatation. In Blakeslee's<sup>52</sup> series, the mortality was 50 per cent. These findings are not only of prognostic, but also of diagnostic value in that the dilatation and fixation almost invariably occur on the side of the injury and are usually the result of hemorrhage. In Macewen's<sup>53</sup> series in which these ocular phenomena were present, there was invariably a fracture of the middle cerebral fossa and in those cases in which a necropsy was performed, a large hematoma was found. McClure and Crawford<sup>3</sup> and McCreery and Berry<sup>41</sup> found that unilateral fixation and dilatation of the pupil occurred on the side of the cranial cerebral lesion. Similar observations have been made by Holman and Scott,<sup>51</sup> Blakeslee,<sup>52</sup> Lyerly,<sup>59</sup> and Gunn,<sup>58</sup> who also state that the phenomenon is usually caused by intracranial hemorrhage.

Less ominous is bilateral dilatation of the pupils without fixation. In Blakeslee's<sup>52</sup> series there was a 30 per cent mortality in those patients presenting these ocular signs. In Stewart's<sup>13</sup> series, 63 patients showed no abnormal findings except inequality of the pupils, 46 of whom recovered and 17 died, whereas in McCreery and Berry's<sup>11</sup> 41 patients in whom an inequality of the pupils was present, only 5 recovered and 36 died. Of the patients in Blakeslee's<sup>52</sup> series presenting inequality with neither dilatation nor contraction of the pupils, 44 per cent died, whereas of those in whom the pupils were equal and neither dilated nor contracted, 32 per cent died.

Contraction of the pupils is found less frequently than dilatation in cases of cerebral injury. In Blakeslee's<sup>52</sup> series of 378 patients exhibiting pupillary changes, myosis was present in only 62 (16.7 per cent). Stewart<sup>13</sup> is of the opinion that the pupil is first contracted and later becomes dilated. Of Blakeslee's<sup>52</sup> 62 patients with myosis, in 20 the pupils were fixed (mortality rate 76 per cent), and in 42 the pupils reacted to light (mortality rate 40 per cent). According to French<sup>59</sup> bilateral pinpoint pupils are suggestive of pontine hemorrhage, whereas Sharp<sup>60</sup> believes that a pinpoint pupil is due to cortical irritation by a supracortical hemorrhage.

The exact mechanism of the pupillary changes is not entirely understood. One recalls that dilatation and contraction of the pupils are produced by the muscles of the iris, which has a dual nerve supply. The oculomotor nerve supplies the circular muscle, and stimulation of it produces contraction, whereas paralysis causes dilatation of the pupil. The dilator papillae muscle is supplied by sympathetic fibers which arise in the ciliospinal tract of the cervicothoracic cord. Stimulation of these fibers produces dilatation and paralysis causes contraction of the pupil. Walton<sup>56</sup> believes that processes, either irritative or paralytic, in the ciliospinal tract and not lesions of the third cranial nerve are responsible for pupillary changes. Holman

and Scott,<sup>54</sup> on the other hand, believe that mydriasis associated with cerebral injury is usually the result of injury or compression of the third cranial nerve. In addition to lesions in the efferent nerve, it must be kept in mind that injury to the afferent fibers within the optic nerve may produce pupillary changes by breaking the reflex arc.

Nystagmus is of less significance in cerebral injury than are pupillary changes. It was observed in only 53 patients in Stewart's<sup>13</sup> series of 6135 cases of head injuries. Of these 53 patients, 30 died and 23 recovered. The nystagmus was toward the injured side in 23 cases and toward the uninjured side in 11 cases. McClure and Crawford<sup>3</sup> state that nystagmus is an unfavorable sign. Of Blakeslee's<sup>52</sup> 475 patients of skull fracture in whom there were positive eye findings, nystagmus was found in only 13. Four (30 per cent) of these 13 died.

There is some controversy concerning the value of eye ground examination in craniocerebral injury. In Blakeslee's<sup>52</sup> series of cases, papillitis with slight swelling of the vessel together with slight edema and obliteration of the disc margin was recorded in only 18 of the 610 cases of fracture of the skull. Thirty-nine per cent of these patients, however, died. Thorning<sup>45</sup> is convinced that eyeground examinations are of relatively little value. In 4 of the 12 cases examined by him, the fundic changes were definite, but in these cases the clinical signs were so pronounced that the condition of the optic disc did not influence the treatment. There were other cases in which the signs were indefinite from the standpoint of the eyegrounds, but in which there were additional diagnostic signs and in which at operation lesions producing increased intracranial pressure were found. Gunn,<sup>55</sup> on the other hand, believes that early changes in the optic disc are of value. He states that there is no noticeable change within six hours following injury. The first change is an increase of the size of the retinal vein, which is accompanied by a hyperemia of



the disc and followed shortly by an edema of the nasal half of the disc. According to Gunn<sup>58</sup> and Cohen,<sup>55</sup> choked disc is never seen in cases of acute craniocerebral injury. In McClure and Crawford's<sup>3</sup> series a choked disc was a late phenomenon, but engorgement of the veins and a haziness of the disc margin occurred relatively early. According to McCreery and Berry<sup>41</sup> a fundic examination is, with the exception of spinal tap, the simplest and most direct way of determining increased intracranial pressure. In Cohen's<sup>55</sup> series of 24 fatal cases of skull fracture, the fundus was normal in 8; there was neuroretinitis in 3; mild bilateral papillitis in 3; mild unilateral papillitis in 1; moderate papillitis in 1; retinal hemorrhage in 2, and no examination in 5. The fundic changes in the non-fatal cases were normal in 35; there was unilateral primary atrophy in 3, and mild papillitis in 3. Green<sup>8</sup> states that the retinal changes which occur as the result of progressive increases in intracranial pressure are: (1) engorgement of the retinal veins and increase in size of the retinal artery; (2) obliteration of the outline in first the nasal and later in the temporal sides of the disc; (3) complete obliteration of the disc. If the edema is over two diameters, a choked disc may be said to be present.

#### BLOOD PRESSURE

To Kocher<sup>30</sup> belongs credit for calling attention to the rise in blood pressure which accompanies rapidly increasing intracranial pressure and which is dependent upon medullary anemia with subsequent vasomotor regulation. Cushing,<sup>61</sup> in 1902, stated:

When, however, the local process is in the proximity of, or, if remote, when its effects are so far reaching that the vital centers of the bulb are compromised, the one symptom which with regularity is called forth, and which betokens a serious alteration in the local circulation is a persisting rise in blood pressure, which may or may not be associated with a pronounced vagus pulse, with rhythmic altera-

tions in blood pressure, and with a retardation or periodicities of the respiration approaching a Cheyne-Stokes type.

Up until the last decade considerable dependence was placed upon blood pressure readings in cases of acute craniocerebral injuries. It is now generally accepted, however, that in acute cerebral injuries little dependence should be placed upon the blood pressure findings (Holbrook<sup>9</sup>) and that when blood pressure changes do occur as the result of cerebral compression, considerable damage has already been done to the cerebrum and medullary centers. Blood pressure readings are, of course, invaluable in the diagnosis and in determining the progress in cases of acute craniocerebral injury in which there is an associated shock. Bower<sup>44</sup> found that there is no constant direct relationship between the cerebro-spinal fluid pressure and the blood pressure. Holbrook<sup>9</sup> has observed many cases in which there was marked increased intracranial pressure, but in which there was no significant blood pressure change. This is also supported by Stewart's findings in 617 cases of skull fracture. The high average blood pressure in the series was, systolic 140, diastolic 77 mm. of mercury, whereas the low average was, systolic 117 and diastolic 71 mm. of mercury. The unreliability of placing too much dependence on blood pressure findings in the diagnosis of acute craniocerebral injury has recently been emphasized by Gage,<sup>62</sup> Fay<sup>11</sup> considers blood pressure determinations of great importance in acute head injuries. The diastolic pressure which represents the resistance offered the circulating blood is most important. Without sufficient tension (diastolic) there is rapid loss of oxygen, so that the blood reaching the capillary bed contains relatively little of it. As Landis<sup>46</sup> has shown anoxemia increases the permeability of the vessels with a resulting edema. In this way a vicious circle is set up. Fay<sup>11</sup> believes that the diastolic blood pressure must be kept above 40 mm. of mercury. Henschen<sup>21</sup> believes that blood pressure determina-

tions may have a localizing value as he has found that the blood pressure reading on the side of injury is often 20 mm. greater

spinal fluid pressure would be of great value as regards diagnosis, prognosis, and treatment (Chart 2). Fay<sup>11</sup> states:

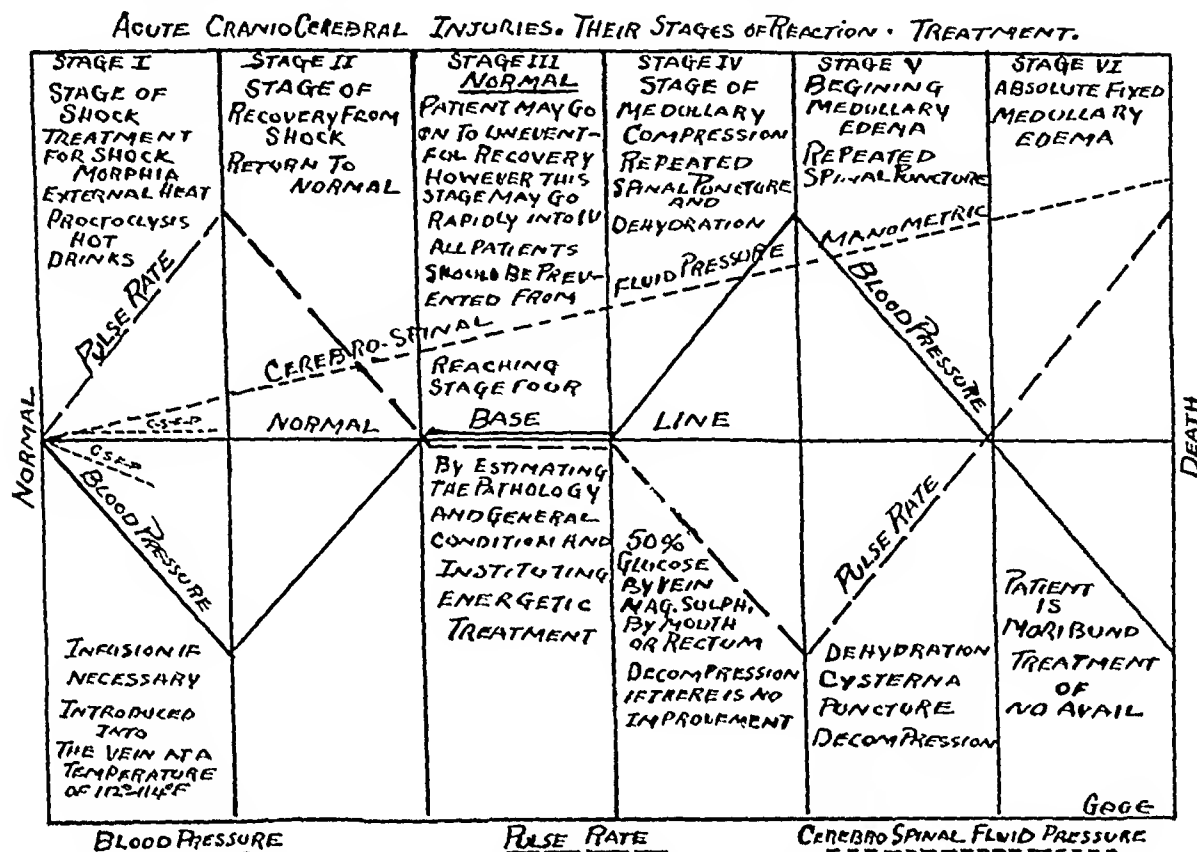


CHART 2. Stages through which patients with acute craniocerebral injuries may pass in those cases in which the lesion is progressive. It is evident that the pulse rate and blood pressure vary considerably with the degree of shock and increase in intracranial pressure. Stage III represents that period after the patient has recovered from shock, at which time pulse rate and blood pressure determinations may be normal, yet in which there may be an increased intracranial pressure. This can be determined only by the determination of cerebrospinal fluid pressure. (After Gage, I. M. AM. J. SURG., 6: 64, 1929.)

than it is on the uninjured side. Experimentally, Jackson<sup>22</sup> found that the application of pressure over the temporal and parietal regions produced no change in blood pressure, whereas pressure applied to the medulla caused first a slight rise and later a fall in blood pressure.

#### THE SPINAL FLUID

Of greatest importance from a diagnostic and prognostic point of view is the determination of the cerebrospinal fluid pressure, as well as the character of the fluid. As the immediate symptoms in acute craniocerebral injuries are the result of increased intracranial pressure, except in those cases where there has been extensive injury of the cerebrum, a knowledge of the cerebro-

A lumbar puncture with careful manometric pressure readings must be done and irrespective of the claims made by those opposed to lumbar puncture, an intelligent management of the case is impossible without knowledge of the pressure mechanism and the presence of bloody spinal fluid, which is frequently encountered where no signs or symptoms may disclose its presence.

Jackson,<sup>22</sup> in 1922, reported his results in 100 cases of acute cranial injuries in which spinal fluid pressure determinations were made and in which spinal tap was used therapeutically. The cerebrospinal fluid pressure was above 30 mm. of mercury in 14 per cent of his cases, the highest reading being 60 mm. In 34 per cent the pressure was between 20 and 30, and in 44 per cent



the pressure varied between 10 and 20 mm. of mercury. Bower,<sup>44</sup> in 1923, reported that lumbar puncture had been used routinely in all cases of craniocerebral injuries at the Samaritan Hospital for a period of seven years and no untoward results had been observed. He emphasized the importance of using a needle with a three-way stopcock in order to prevent an escape of cerebrospinal fluid. In a series of 316 cases admitted to the Boston City Hospital and analyzed by Munro,<sup>63</sup> lumbar puncture was performed and manometric readings of the cerebrospinal fluid pressure were made in 36. In the patients who recovered, the highest pressure recorded was 60, the lowest was 4, and the average 16 mm. of mercury. In 7 fatal cases the highest pressure was 100, the lowest 10, and the average 39 mm. of mercury. Spinal puncture was performed in 414 of McCreery and Berry's<sup>41</sup> 520 cases of cranial fracture. The spinal fluid pressure was increased in 209, normal in 185, decreased in 12, and not noted in 6 of their cases. They believe that spinal puncture is of great diagnostic value. In comparing the differences in cerebrospinal fluid pressure in cases of craniocerebral injuries between the white and colored races, Weaver<sup>49</sup> found that among 300 cases occurring in the white race, there were 190 cases of hypertonicity as compared with 218 cases among 300 occurring in the colored. Connors,<sup>12</sup> Fay,<sup>11</sup> Holbrook,<sup>9</sup> and Symonds<sup>27</sup> believe that a diagnostic lumbar puncture should be made routinely in cases of acute craniocerebral injuries. Newell<sup>5</sup> employs manometric readings of the spinal fluid, but believes that other methods of examination are more important. McClure and Crawford<sup>2</sup> are of the opinion that lumbar puncture should be done only when there is a definite indication. They state that it should be done slowly and cautiously. In their series of 441 cases, lumbar puncture was performed in 148 cases or 33.6 per cent. Forty-seven and three tenths per cent had pressures under 10 mm. of mercury, 30.8 per cent

from 11 to 20, 10.8 per cent from 21 to 30, and 2 per cent above 30 mm. of mercury. In Munro's<sup>63</sup> series of cases the comparison of the spinal fluid pressures in the fatal and non-fatal cases reveals that the average intracranial pressure is nearly two and a half times higher in the fatal than in the non-fatal cases. Even though it is desirable to perform a lumbar puncture and determine the cerebrospinal fluid pressure as soon as possible after an acute craniocerebral injury, it is generally accepted by most authors that this procedure should not be performed in the presence of shock. Aside from the fact that patients in shock bear any operative manipulation poorly, lumbar puncture performed at this time is of relatively little diagnostic aid, as even in those cases in which there is extensive cerebral injury, the cerebrospinal fluid pressure is apt to be normal or decreased, because of the decreased arterial and venous pressures.

Aside from the determination of the cerebrospinal fluid pressure, a knowledge of the character of cerebrospinal fluid is of great value as regards prognosis and treatment in craniocerebral injuries. Thirty-nine and nine tenths per cent of the 148 cases in which lumbar puncture was done in McClure and Crawford's<sup>2</sup> series, the spinal fluid was bloody and it was clear in 60.1 per cent. Eighty-three and three tenths per cent of their cases in which death occurred, the spinal fluid was bloody. In Munro's<sup>63</sup> series the spinal fluid contained blood in 57 cases and was clear in 26. In Stewart's<sup>13</sup> series, lumbar puncture was performed in 165 cases, bloody fluid was obtained in 90.5 per cent, and clear fluid in 10.4 per cent. In 47 cases in which lumbar puncture was made in Vance's series of cases, bloody fluid was found in all three tubes in 39. In the 414 cases in which a lumbar puncture was made in McCreery and Berry's<sup>41</sup> series, the fluid was clear in 13, contained blood in 398, and contained pus in 3. The authors believe that blood rarely occurs in the cerebrospinal fluid in traumatic cases unless there is an asso-

ciated cranial fracture. Aside from indicating the severity of the lesion, blood within the cerebrospinal fluid is of importance as far as treatment and subsequent sequelae are concerned. Essick<sup>31</sup> found experimentally that when laked blood was injected into the subarachnoid space, there occurred within six hours a definite sterile meningitis. Bagley<sup>32</sup> was able to demonstrate experimentally that blood injected into the subarachnoid space of dogs produced marked systemic changes. Immediately after the injections the animals became spastic and recovered from the narcosis slowly. In the adult animals there frequently followed convulsive movements and frothing at the mouth. The animals were hypersensitive, irritable, and the nutrition was poor. In puppies the most startling effect was noted, in that there was a diminished activity and a poor development. Late in the course of the meningeal reaction, changes in the cortex were observed. In 6 out of 19 puppies in which blood was injected into the subarachnoid space and on which autopsies were performed, a definite dilatation of the ventricles was found. Fay<sup>34</sup> has described a type of cerebral atrophy caused by collections of fluid in the subarachnoid space, which is a sequel to subarachnoid hemorrhage.

In contrast to the authors already mentioned, there are certain authorities who believe that lumbar puncture is dangerous and should not be performed in cases of craniocerebral injury in which an increased intracranial pressure is suspected. These authorities believe that because of the sudden decrease in the intraspinal pressure, a herniation of the medulla into the foramen magnum may occur. McClure and Crawford<sup>3</sup> believe that lumbar puncture should be done only in selected cases and that the cerebrospinal fluid should be withdrawn slowly and carefully. Henschen<sup>21</sup> is of the opinion that lumbar puncture is dangerous and should never be used in the presence of increased intracranial pressure. Besley<sup>47</sup> believes that

lumbar puncture is not free from danger. Sachs<sup>64</sup> is also definitely opposed to lumbar puncture in acute craniocerebral injury.

As a localizing sign Muck<sup>65</sup> has been employing a phenomenon which he observed and reported in 1924. He found that in certain patients with cerebral lesions if the nose were sprayed with a 1:1000 adrenalin solution, following which the nasal mucosa on the anterior end of the anterior turbinate were stroked by means of a smooth probe, that a white line, which persisted from fifteen to thirty minutes, occurred at the point of contact with the probe. Normally, a red line appeared at the point of contact with the probe in the anemic area produced by the adrenalin, all of which disappeared in about fifteen minutes. The white line here described persisted long after the anemia produced by the adrenalin had disappeared. In his original publications Muck<sup>65</sup> stated that this phenomenon occurred in patients with migraine, brain tumors, and in patients with brain injuries. He believes that the reaction is due to a hyperactivity of the sympathetic fibers, resulting in increased irritability of the vasoconstrictors of the nasal mucosa. In subsequent publications Muck<sup>66-69</sup> states that this phenomenon occurred on the side of injury and believes that it is indicative of injury to the pia. In the examination of over 200 cases of craniocerebral injuries, he<sup>67</sup> found that the white line sign was regularly present and almost without exception on the injured side. In 49 left-sided injuries the white line was on the left side in all but 9 and on both sides in one of these 9. Of 38 left-sided parietal injuries the phenomenon was present on the left side in 35, on the right side in 3, on both sides in 11. Of 131 either right or left-sided injuries the phenomenon was present on the contralateral side in only 13. In 1929 Muck<sup>68</sup> reported 92 cases of cerebral injuries examined by this method, and states that if the injury involves either of the hemispheres the phenomenon is present always on the homolateral side. It is not positive

in injuries of the facial bones, injuries of the scalp, and extradural wounds. As the phenomenon is also present in cases with cerebrospinal syphilis, epidemic meningitis, and lethargic encephalitis, it is important that these conditions be excluded when employing the test. Muck's observations have been confirmed by Joel.<sup>70</sup>

#### ROENTGENOGRAPHY

The relative importance of roentgenography in the diagnosis of craniocerebral injuries is a matter of controversy. It may be stated, however, that all cases of acute craniocerebral injury should have roentgenograms of the skull for two possible reasons: (1) in order to eliminate the possibility of a depressed fracture, a knowledge of which is absolutely essential in order that the correct and proper therapy be instituted; (2) because of the high regard which the laity and the legal profession have for cranial fractures. A failure to obtain a roentgenogram in a suspected cranial lesion, especially in a medico-legal case, would indicate, at least in the eyes of a jury, improper care of the patient. It is obvious that a roentgenogram will show only cranial and not cerebral lesions. It must not be forgotten that aside from depressed fractures, the most important lesion in craniocerebral injuries is not the injury to the cranium but the cerebral lesion. Fay<sup>11</sup> even advocates making no roentgenogram when the patient is first seen, because the plates are usually of

little value and if a depressed fracture of such a degree is present, which will require elevation, it can be recognized at the initial examination. Roentgenograms, also, are not infallible, even in cases of cranial fracture, as illustrated by the following studies: In Stewart's<sup>13</sup> series of 617 cases of cranial fracture only 73.1 per cent of the fractures showed positive roentgenologic evidence of fracture, whereas 26.8 per cent gave negative results. In the latter group 10.7 per cent showed linear fractures at the time of operation and 12.3 per cent were diagnosed as basal fractures by other signs and symptoms. Eleven and six-tenths per cent were found to have basal fractures at post-mortem examination; 2 per cent proved to be fractures of the vault, which were slightly depressed when the wound was explored. Roentgenograms were made in 80.3 per cent of the 441 cases of acute craniocerebral injuries reported by McClure and Crawford.<sup>3</sup> In only 35.9 per cent of the cases in which roentgenograms were made was evidence of fracture obtained; in 10.7 per cent of the clinically positive cases roentgenograms were reported negative, and in 2.8 per cent of the cases there was roentgenologic evidence of fracture in the absence of positive clinical signs. In the 520 cases of cranial fracture reported by McCreery and Berry<sup>11</sup> x-ray examinations were made in 220 cases and found negative in 61 per cent. Fractures of the vault were found in 75 of the cases and fracture of the base in only 13.

(To Be Concluded in June)

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# RADIUM THERAPY OF TUMORS OF THE GENITOURINARY TRACT\*

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SOME fifteen or twenty years ago radium was first tried as a therapeutic agent in malignant diseases of the prostate, bladder, penis and testicle. The reason for its trial is obvious. Surgery had proved to be singularly inadequate in attempting to control these diseases. For a good many years surgery had devised and perfected new and elaborate operations in its attempt to cope with them. As a rule, the more elaborate the operations the higher the operative mortality became. Instance total cystectomy with implantation of the ureters into the bowel with a mortality of upwards of 50 per cent. This increasing operative mortality might have been justified if more cases had been cured. This was not the case.

Because it had a definite specific effect upon cancerous tissue, radium was suggested as a substitute for surgery. After fifteen years of work at the Memorial Hospital, work in which successes mingled with failures, it seems that today the original faith that radium might prove of value in controlling cancer has been more than justified.

Let me here interject that radium treatment of any malignant disease is becoming more and more a problem that can best be dealt with in especially equipped hospitals. Radium is expensive. Its proper use implies a certain amount of special training. Many of the failures of radiation therapy are due to the fact that sufficient amounts of radium are not at hand when any particular case is dealt with. The effect is the same as if a surgeon sliced off a small part of a tumor, rather than removed it in its entirety.

And just one word about radium burns. It is impossible to eradicate a tumor without causing some radium effect upon

the surrounding tissues. This is the so-called and much feared radium burn. My point of view for a great many years has been that I fear the cancer much more than the radium burn. The one causes death. The other is a transient affair.

Let us see how radium therapy has affected the treatment, the prognosis and our general conception of the control of 4 genitourinary carcinoma: cancer of the penis, teratoma of the testicle, cancer of the prostate and cancer of the bladder.

## CARCINOMA OF THE PENIS

The older conception of the cure of carcinoma of the penis did not distinguish at all between the different forms and different locations of the carcinoma, and it was believed that all cases should be treated with amputation of the penis at the triangular ligament, with implantation of the urethra in the perineum, and at the same time bilateral dissection of the glands of both inguinal regions. A careful study of these cases has revealed the following facts: That the carcinoma may be papillary in type, and may be entirely confined to the foreskin, or it may be entirely confined to the glans penis, or it may be a combination of these two; that it may be of the infiltrating type, growing into the substance of the penis, penetrating Buck's fascia, and so growing up along the corpora cavernosa; that involvement of the inguinal glands by the carcinoma is rare; that infection of the inguinal glands without cancerous involvement is quite common; that when the inguinal glands are both cancerous and infected routine dissection has little or no chance of controlling the cancer. Therefore, our therapy at present is as follows: The foreskin must be freed either by dorsal slit or by circumcision, so elimi-

\* Read at the St. Louis Clinics June, 1930. From the Dept. of Urology, Memorial Hospital, N. Y.

nating the causative factor of carcinoma, the irritating secretion. In 3 recent consecutive cases, the carcinoma was entirely confined to the foreskin, and simple circumcision eliminated the carcinoma. All of these patients are well five years after. Two had no further therapy. The third had a recurrence which necessitated amputation of 1 in. of the penis. He is well five years after.

When the carcinoma is papillary in type, or if infiltrating and if Buck's fascia has been penetrated but a slight distance, then operation may be entirely eliminated, and the carcinoma controlled by radium, as a rule applied on the surface.

We are seeking to further extend the field of radium in the infiltrating type, and while formerly we believed that few could be controlled in this way, we are now applying it to more cases with deeper infiltration. On the other hand if the infiltration is extensive then we excise the penis 2 cm. beyond the growth. The excised portion is dissected at the operating table to determine accurately if we are beyond the growth. No routine inguinal dissection is done. The infection of the inguinal glands is eliminated by its control at the source, the penis. The inguinal glands are treated by a combination of deep x-ray therapy and radium pack, with implantation of radium in any suspicious glands.

If the primary lesion is confined to the foreskin it is removed by circumcision, and any suspicious areas remaining are irradiated. If the primary lesion is 2 cm. or less in diameter, superficial, and metastases cannot be detected, external irradiation alone is used. The tumor is treated with a radium plaque,\* the dose being 1200 mc. hours per square centimeter, at 1 cm. distance.

There were 13 patients in this group. Twelve, or 92 per cent, are living, without signs of disease. One patient died at another hospital following an operation. One of

\*The plaque is a box 1 cm. square which contains radium emanation enclosed in silver capsules, the walls of which are 0.5 mm. thick. The side of the box which overlies the tumor is made of brass, 1 mm. in thickness.

these men lived from twelve to eighteen months; 3 from eighteen to twenty-four months; 1, from two to three years; 2, from three to four years; 2, from four to five years; 2, from seven to eight years and 1, for nine years four months after the first irradiation.

Occasionally, the carcinoma, though small, has penetrated deeply into the cavernous tissues. Frequently, undermining has gone so far that the deeper parts of the tumor are relatively inaccessible to intense external irradiation. In such cases irradiation with the plaque is followed by a conservative amputation.† Four patients were so treated. All of them are living and well; 1, from two to three years; 2, from four to five years and 1, from six to seven years after the first irradiation.

If the primary tumor is larger than 2 cm. in diameter and metastases are not found, the treatment of choice is usually irradiation with the plaque followed in from three to four weeks by a conservative amputation. On those patients who present extensive tumors which have already destroyed a considerable proportion of the penis, a similar amputation is performed without preoperative irradiation.

In this group there were 31 patients. Nineteen, or 61 per cent, are living and well; 5, or 16 per cent, are known to be dead, while 7, or 22 per cent, are lost from the records and are classified as dead. The living have survived: 1, from eighteen to twenty-four months; 4, from two to three years; 2, from three to four years; 4, from four to five years; 3, from five to six years; 4, from seven to eight years and 1, from eight to nine years after the first irradiation.

Eighteen patients were first seen with both a primary lesion and metastases. Three, or 16 per cent, are living, 2 with signs of disease; 15, or 82 per cent, are dead.

†Conservative operation is believed to be a distinct advance in rational therapy. Amputation is performed 2 cm. proximal to visible or palpable evidence of disease. The success of the measure depends on the knowledge that metastasis is by embolism. It is not at all uncommon to preserve so much of the organ that coitus is possible.



Therefore, of 66 patients, 36, or 57.5 per cent are alive, and as far as can be determined, free of disease. *And more, there has been no operative mortality.*

#### TERATOMA OF THE TESTIS

In no tumor has radiation produced more brilliant results than in this disease. The pathology of the disease is that the teratoma starts in the rete testis, then grows either toward the testicle or epididymis, or both. Then it metastasizes by way of the veins or lymphatics, or both. Metastases form along the course of the spermatic vessels.

This has suggested to many (Hinman and others) that the cure was to remove the testicle, and by extensive dissection of the retroperitoneal glands, to eliminate all of the carcinoma.

This has never appealed to me as a feasible way to control retroperitoneal metastasis.

Our course of procedure is as follows: In the primary cases, in which no surgery has been done, the testicle is thoroughly irradiated with the radium pack. The course of the spermatic vessels on the side affected is also thoroughly radiated by radium pack or deep x-ray therapy. The only operation that is done is the removal of the testicle under local anesthesia. The cord is cut first, and the testicle is removed from its bed afterward, care being taken not to squeeze the testicle, and so preventing the dissemination of the cancer. This operation is done about two months after the first radiation, and has no mortality.

At the time this article is written we are able to present data on 113 patients treated and followed in this hospital. Of these 113 cases, 41 are living and clinically free from disease. The table indicates the time duration:

9 -12 months.....	1	4- 5 years.....	3
1 -1.5 years.....	5	5- 6 years.....	3
1.5- 2 years.....	9	6- 7 years.....	2
2 -2.5 years.....	6	7- 8 years.....	0
2.5- 3 years.....	2	8- 9 years.....	2
3 - 4 years.....	6	9-10 years.....	1
		10 years.....	1

The following case report is of interest.

The patient was a negro chauffeur, aged thirty-seven years. He was admitted to the hospital in May, 1925, with a history of painless swelling of the right testis over a period of five months. The testis steadily increased in size and two weeks before admission first became painful. Three months prior to entering the hospital the patient began to cough and had frequent night sweats. He had lost 36 lb. in weight. Examination revealed a tumor of the right testis measuring 14 cm. in circumference. A mass 5 X 7 cm. was palpated in the right abdomen and x-rays of the chest showed extensive pulmonary metastases. In addition there was a hard supraclavicular node measuring 1 X 2 cm. No operation was done. The patient was treated with a great deal of high voltage x-ray and with radium. The testis was reduced to a firm fibrotic mass. The metastases disappeared and the patient is now clinically well and free from demonstrable disease for four and a half years from the time treatment was first instituted. The skin shows practically no effect from the treatment.

#### CARCINOMA OF THE PROSTATE

Carcinoma of the prostate still holds its place as the great urological puzzle. We know next to nothing as to its cause. We have no real, practical method in general use to make the diagnosis of this condition sufficiently early to give any sort of treatment a fair chance of success. If we by hazard make an early diagnosis of carcinoma of the prostate we are thoroughly in a muddle as to the best way to control this carcinoma. This paper is written in an attempt to analyze the reasons for our failures in the past and with a look toward the future.

We have found that in but between 2 to 5 per cent of all cases seen at the Memorial Hospital is the carcinoma confined to the prostate. Young reports 27 radical operations for carcinoma of the prostate, the first in 1904 and the last in 1927,<sup>1</sup> just a little over one a year. This would seem to indicate how very few cases come to his service which he believes are appropriate

<sup>1</sup>Lewis, D. Practice of Surgery. Vol. 9, Chap. 21, p. 94.



for radical operation. Wildbolz operated upon 40 out of 145 patients with prostatic carcinoma.<sup>2</sup>

It seems superfluous to say that earlier diagnosis is of prime importance, and earlier diagnosis by means of pathological examination. A method for obtaining a specimen from the suspected prostate has been perfected by one of our staff. This is done with a simple aspirating needle, and it is effective in 66 per cent of cases. A discussion of the various methods to control prostatic carcinoma after an early diagnosis has been made reveals the fact that no two urologists seem to be in accord as to the best way to accomplish this.

A review of the use of radium in carcinoma of the prostate at the Memorial Hospital has revealed the following interesting facts: From October, 1915 to January, 1917, we saw 46 cases of prostatic carcinoma at the Memorial Hospital. In but one of these cases was the carcinoma confined to the prostate. Five of the 46 patients lived more than five years. None of these 5 cases, as far as we could see, had any gross evidence of active carcinoma. These cases were treated by the insertion of steel radium-bearing needles through the perineum into the prostate and seminal vesicles, giving small doses, 200 or 300 mc. hours for each needle, and then repeating this dose every two or three months until the condition was controlled or not. In this way we were certainly able to cure some cases, as we have had the autopsy of one patient who died seven years after first seen; the diagnosis of carcinoma was made from the prostate removed before operation, and the autopsy showed no carcinoma anywhere.

Since that first series we have not done as well. We have been in a transition state, changing to gold seeds and have pretty thoroughly come to the conclusion that gold seeds cannot be implanted through the perineum into the prostate with any

great degree of accuracy. We believe that in most cases of prostatic carcinoma a much larger dose of radium than heretofore used is necessary to control the disease; in other words, doses comparable to those we have used in controlling bladder carcinoma.

A certain percentage of prostatic carcinoma are highly malignant and radio-sensitive. Because of this I believe that all cases of prostatic carcinoma, before anything is done, should be subjected to a thorough cycle of deep x-ray radiation, using five portals of entry. This at best gives only about 1½ erythema doses to the prostate, whereas we believe that somewhere between 10 and 15 erythema doses are necessary to control the large majority of prostatic carcinoma. Because of the necessity for a large dose of radium accurately placed within the prostate I have quite reversed my original contention that the best method was through the perineum. I believe that cystotomy should be done, any obstructive portions of the prostate removed with cutting forceps or a cautery, and the entire tumor, periprostata, periprostatic region and seminal vesicles, if they are involved, implanted with radium seeds, using seeds of 2 mc. each to every centimeter of tumor. It seems to me that the suprapubic exposure is better for this purpose than the perineal one, because the seeds can be more accurately placed and because the prostatic region is not dissected up, so reducing its value as a productive barrier to the radium seeds.

The mortality of this operation is not so great as that of Young's radical removal, and while it is not a beautiful piece of technique, I believe it will prove in the long run a much more effective method to control prostatic carcinoma, one that can be used by many more urologists. It will certainly offer a sure way of controlling the bladder invasion of the carcinoma which so frequently occurs in the glands of Albarran and the bladder base.

#### CANCER OF THE BLADDER

The treatment of bladder tumors is still

<sup>2</sup> Wildbolz, H. Die Erfolge operativer Therapie des Prostatakarzinoms. *Schweiz. med. Wchnschr.*, 58: 726, 1928.

in a state of evolution. Surgery and radium have been and still continue to be contestants for honors.

A comparison between the results of the radium implantation and operative removal of bladder cancer is difficult because surgery picks the cases which are operable and discards the rest.

At the Memorial Hospital we have subjected to radiation every patient with bladder cancer in whom the cancer was believed to be confined to the bladder, no matter how large the tumor was. Therefore, in this series are included many inoperable cases. In a fair percentage of cases the tumor occupied one-third or more of the bladder. In these cases 28 per cent were tumors whose bases were 6 sq. cm. or under.

In 72 per cent the cases were greater than 6 sq. cm.

*The Location of the Tumor:* In 127 tumors 81, or 63 per cent, touched or were adjacent to the trigone. Many of these would have required total cystotomy if operative removal had been contemplated.

In 19, or 15 per cent, the location was on the base posterior to the trigone. In 18, or 14 per cent, the tumor was on the lateral walls and easily removable.

In 1, or 7 per cent, it was on the apex. In 8 the site was not designated.

In the 63 per cent of tumors touching the trigone the operative mortality following the surgical removal of these tumors, if that were possible, would have been between 10 per cent and 20 per cent, and a fair number of these tumors could not have been removed surgically.

TABLE 1

## PAPILLARY CARCINOMA

## Diagnosis, Clinical

(Papilloma with atypical cells are grouped under this heading)

Cases: 45

Clinical and pathological diagnosis agree—36

Clinical and pathological diagnosis disagree—9

Controlled: 30 cases—66 per cent

Controlled over three years: 25 cases—55.5 per cent

1	1-2	2-3	3-4	4-5	5-6	6-7
1	3	0	2	6	3	3
7-8	8-9	9-10	10-11	11-12	12-13	
2	2	5	1	0	1	

Not controlled: 15 cases—33 per cent

## INFILTRATING CARCINOMA

## Diagnosis, Clinical

Cases: 82

Clinical and pathological diagnosis agree—47

Clinical and pathological diagnosis disagree—35

Controlled: 30 cases—36.5 per cent

Controlled over three years: 23 cases—27.8 per cent

1	1-2	2-3	3-4	4-5	5-6	6-7
3	2	2	4	3	3	4
7-8	8-9	9-10	10-11	11-12	12-13	13-14
3	2	3	....	.....	.....	1

Not controlled: 52 cases—63.5 per cent

## DIFFERENT FORMS OF RADIATION

We have been able from the very start (1914), to control a good percentage of malignant bladder tumors with radium. We first used screened radium applied in a somewhat hit or miss manner. Then partly screened and partly unscreened (glass seeds), more accurately applied, but with much caustic beta radiation. And finally accurately applied gold seeds giving off no beta radiation.

Beta radiation certainly causes sloughy anus of the bladder, which only too often becomes covered with troublesome phosphatic deposits. On the other hand two of the most malignant tumors we have ever controlled were controlled solely by glass seeds.

It is an open question at present whether or not this caustic action of beta radiation is a factor in controlling bladder cancer.

The size of the dose of radium is an important factor. The reason why many who use radium fail is that a very small dose is used. I have analyzed a good many such cases and have found almost without exception this to be the reason for failure.

One gold seed of 2 mc. hours to  $1\frac{1}{2}$  sq. cm. of tumor is a *minimum dose*. I have

put as many as 40 such seeds in a single very large tumor. Considerable bladder irritability and some rectal irritation may follow this dosage (if the seeds be near the rectum), and the so-called radium burns may follow this administration.

I have always worried more about the malignancy of a bladder tumor than over a radium burn. We have calculated that about ten times an erythema dose is necessary to control the radioresistant tumors. This accounts for the reason that deep x-ray therapy so often fails. It is difficult to get into the tumor by this means much more than  $1\frac{1}{2}$  erythema doses.

#### THE SUPRAPUBIC OPERATION

Finally, let me stress the decided difference between the operative mortality when a tumor is removed by surgery and when it is implanted by radium by the suprapubic route. In 109 consecutive personal cases of the suprapubic implantation of radium 4 patients died in the hospital, an operative mortality of 3.6 per cent. One died of shock and hemorrhage, notwithstanding two blood transfusions, 1 of diabetic coma, 1 of uremia,

1 of shock; a poor heart and old age contributed.

A considerable number of these cases would have been classed as inoperable.

Operative removal in these cases of this series which were operable would have been between 10 per cent and 20 per cent.

In doing the suprapubic implantation spinal anesthesia should be used, the bladder should not be mobilized; the abdominal wound should be thoroughly screened with gauze before opening the bladder; great care should be taken not to spill the bladder contents over the wound; a good exposure of the tumor is necessary; the Cameron light should be used for retraction and to illuminate the bladder; open wire retractors devised by us at the Memorial Hospital are very useful for a good exposure of the tumor; the papillary portions of a tumor should be removed by some form of cautery; the radium implantation should be very accurate; a small suprapubic drainage tube (18 to 22° F.) should be left in place for about a week or longer, if the bladder is dirty or the radium dose is very large; the bladder is not sutured to the abdominal wall.



# ALLERGY AS A CAUSE OF GASTROINTESTINAL DISORDER\*

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**A**LLERGY is important in its relationship to the gastrointestinal tract not only because it can produce serious gastrointestinal disorder, but also because it can simulate both functional and organic disease due to other causes. Consequently, unless recognized, it can lead to gross error in diagnosis. It is important also because the gastrointestinal turmoil caused by allergy can actually precipitate organic disease which may require surgery for relief. It is important, finally, because therapeutic measures for the relief of gastrointestinal allergy are sensationally effective if adequately administered.

Allergy can involve almost every active tissue. It is characterized by certain features which make its recognition relatively simple and certain. A physician can diagnose the condition correctly, as a rule, if he is well acquainted with the subject. Allergy can simulate a large variety of diseases but rarely simulates any of them perfectly. It should be looked for whenever the symptoms displayed by a patient do not fit well with known disease patterns.

The typical local lesion of allergy is characterized by anemia, and eosinophilic infiltration of the part directly affected and a surrounding area of erythema. Typically, this constitutes a hive. It is associated usually with sensory disturbance such as itching and, in the gastric tissues, sometimes by pain. In addition to this, there is a disorder which occurs as part of a general reaction of allergy. This consists basically of over-activity of one or more or all of the branches of the vagus system. It causes anomaly in muscle contraction and in secretion. In the case of widespread allergy, shock may result characterized by disappearance of pulse

and respiration, cyanosis, and loss of consciousness. Shock may terminate fatally unless promptly and adequately treated. It is interesting to relate that each of these phases of allergy can be almost immediately relieved within a matter of moments through prompt and adequate use of adrenalin.

Allergy may make its appearance at any point in the gastrointestinal tract from the lips to the rectum, giving rise to the signs of local and general reaction as previously mentioned. It can cause symptoms which may be mild or severe, acute or chronic, intermittent or continuous. The extreme symptoms which are occasionally observed are often alarming. Nausea, vomiting, and diarrhea may equal that caused by any other disease known to medical science. Infiltration of the tissues with edema may cause complete obstruction and finally, pain may equal that caused by gallstone, kidney stone, or gastric crisis. Allergic disorders characterized by anemia and edema of the membranes, increased tone of non-striated muscle and increased secretion, can easily precipitate inflammatory disease in the gastrointestinal tract or its appendages. I have observed a number of cases of acute appendicitis which commenced with an attack of alimentary allergy. I believe the characteristic symptom of acute appendicitis as mentioned in the common textbooks, that is, pain in the epigastrium followed after a day or so by pain and tenderness in the region of the appendix, is frequently caused primarily by gastric allergy which is later followed by a complicating inflammatory disease of the appendix itself.

It was mentioned before that alimentary allergy can simulate many functional and organic diseases but that it rarely simu-

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lates any of them perfectly and can almost always be distinguished from the other diseases. It can be suspected whenever alimentary symptoms do not fit well with the usual symptomatology of other known diseases and especially if the disturbance is associated with other easily recognized symptoms of allergy such as allergic coryza; swelling and itching of the pharynx; hoarseness and edema of the larynx; bronchial cough or asthma; or by skin manifestations such as pruritis, urticaria, angioneurotic edema, or eczema. The condition may also be suspected in the absence of these easily recognized symptoms if a well marked family history of allergic disease can be obtained, or if the condition disappears after a therapeutic test with adrenalin. The severest symptoms of allergy should yield to adrenalin unless complicated by some non-allergic change in the affected tissues. Adrenalin must be administered with precision. Unfortunately, we have no way of determining the ideal dose for a given patient or even for the same patient at different times. It is a good rule, therefore, to give about  $\frac{1}{10}$  c.c. or a little more at five-minute intervals until tremor appears. Tremor usually indicates that the administration has been adequate and that true allergic symptoms should soon subside. If the dose is pushed to the point of causing cardiac arrhythmia or heart pound, a rubber tourniquet should be placed around the arm above the site of inoculation and released at frequent intervals. An excessive adrenalin effect can be stopped promptly in this way (Insley).

Symptoms of alimentary reaction can be divided into two distinct groups: first, those which occur as a result of direct contact between the tissues and the offending agent and, second, those which occur as part of a general reaction caused by contact with a substance after absorption. As an illustration of the former type may be mentioned the violent gastrointestinal symptoms which occur as a result of the ingestion of a small amount of honey in

honey-sensitive cases. Pain, nausea and vomiting occur as a rule within a few minutes of the time of ingestion of the honey and may be shortly followed by symptoms of general reaction. I have observed a case in which the ingestion of honey on two occasions caused gastrointestinal symptoms, immediately followed by a convulsion, coma, complete disappearance of pulse and respiration and cyanosis. The application of honey to the skin in cases of this sort gives rise immediately to a typical hive. This type of case reacts in the same way that pollen-sensitive cases react to the application of pollen.

The second type of reaction (alimentary symptoms occurring as part of a general reaction) is observed typically in the case of alimentary symptoms which may follow an insect bite in hypersensitive persons. Here symptoms such as nausea, vomiting, bloating, diarrhea and collapse may be very severe and may actually, in rare instances, cause dehydration, collapse, and death.

Both these types of reaction may occur simultaneously. This is illustrated in pork-sensitive cases. Here a person may have coryza and headache and gastric disturbance caused by direct contact between the membranes and emanations from the food as it is eaten, and later may have urticaria and other general symptoms occurring as part of a general reaction.

The commonest single cause of alimentary reaction is food sensitiveness. Alimentary reaction caused by sensitiveness to drugs, sera, insects, and animal parasites (including intestinal worms) is less common. Finally, as will be discussed subsequently, symptoms caused by sensitiveness to the effect of heat and effort and to the effect of cold are frequent but less common. Pollen, epidermal substances, dust, smoke and volatile oils which commonly cause nasal and bronchial symptoms are rarely absorbed in quantities sufficient to produce reactions in the alimentary tract.

Reactions to foods are interesting. Symp-

toms which are inclined to be chronic and continuous are almost always caused by a food which is eaten repeatedly. Attacks which occur at rare intervals are usually caused by foods which are rarely eaten. It is much easier to make a diagnosis in the latter case because the patient, as a rule, can notice a relationship between cause and effect. In the case of sensitiveness to foods commonly eaten, such as milk, eggs, and pork, the diagnosis is beset with difficulties, especially if the patient is highly sensitive and reacts to traces of the offensive agent. Infants highly sensitive to egg can actually be made ill by the quantity of egg they receive from the lips of a person who has recently eaten egg. Adults highly sensitive to egg can actually obtain enough egg from the eating of hen meat to be made profoundly ill. I have had two individuals highly sensitive to pork who could be made profoundly ill by the trace of lard contained in a small slice of bread. Also one individual who was so highly sensitive to cane sugar that an illness could be produced by placing one or two granules of sugar on the tongue. Several honey-sensitive patients who were not sensitive to the gross constituents of honey such as sugar, were made ill by the trace of foreign substance contained in one drop of honey. One ragweed-sensitive patient who could tolerate commercial honey of five varieties was made ill by a small quantity of wild honey. This may have been caused by its content of pollen.

Whereas a few individuals are highly sensitive, such as those already mentioned, many patients are slightly sensitive and are made ill only by the eating of definite quantities of the offending agent. This is particularly true in children. Many individuals are brought to a state of invalidism through the eating of normal amounts of milk and eggs and can be completely relieved by their partial avoidance.

There is a type of reaction similar in every sense to the allergy as here described caused by specific sensitiveness to the action of physical agents. I have grouped

these cases together under the term "physical allergy," meaning altered reactivity to the effect of physical agents such as light, heat, cold, and scratches and in the case of heat sensitiveness, to the effect of mental and physical effort). So far as the alimentary tract is concerned, the only reactions to physical agents which are important are those caused by sensitiveness to heat and cold and to the effect of effort. Cases of physical allergy can be divided into two groups of patients: first, those in whom reactions occur only at the point of contact between the tissues and the physical agent and those in whom reactions occur not only at the point of contact but in distant structures as well; in fact, frequently in distant structures only.

Reactions to heat and cold which occur only at the point of contact with heat or cold are rare and in my experience are rarely caused by cold and have but once been caused by heat. Reflex-like reactions, however, that is, reactions which occur in points distant from the point of exposure, are quite common and rather frequently involve the gastrointestinal tract. They can cause gastrointestinal symptoms which may be more or less violent, symptoms such as nausea, vomiting, diarrhea, and pain. Attacks may be associated with other symptoms of physical allergy such as prostration, tremor, headache, allergic coryza, asthma, pruritis, urticaria, angio-neurotic edema, and, occasionally, shock.

Heat reactions of this sort may occur as a result of gross exposure to heat in patients who are slightly sensitive, and as a result of almost infinitesimal exposure to heat in patients who are highly sensitive. In the latter case, as small a quantity of heat as is encountered in the drinking of a cup of coffee with a meal may precipitate an attack, or the physical effort of getting up out of a chair may precipitate an attack, or the mental effort of an interesting business deal, or the watching of an athletic contest, or an emotional disturbance may precipitate an attack. In a

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fashionable woman who was highly sensitive to heat, a vivacious social conversation was likely to be interrupted by acute diarrhea.

The symptoms in patients who are heat or effort sensitive can be reproduced objectively by the application of heat to the skin. In this way, a diagnosis can be proved. The symptoms can be relieved almost immediately by the application of cold to the skin. Interesting to relate, the symptoms can be produced by heating an extremity such as the arm with a hot lamp even though a tourniquet is applied above the point of application so tightly as to stop the circulation of blood. Evidently the symptoms produced in this case are produced through the sense of heat. Interesting to relate also is the fact that an attack generated in this way can be promptly stopped by the application of cold to another extremity even though a tourniquet be applied above the site of application of cold. A patient who is inclined to have symptoms of this sort can frequently relieve himself by as simple a procedure as holding a piece of ice in his hands or immersing his hands and forearms in cold water. The relief which can be obtained frequently in this way in severe cases is nothing short of miraculous.

In the case of cold sensitiveness, we have a reverse status, that is, symptoms such as abdominal pain, nausea, vomiting and diarrhea often associated with other allergic symptoms such as prostration, tremor, urticaria, pruritis, asthma, allergic coryza, etc., caused directly by the effect of cold on the skin or mucous membranes. A cold drink, a cold food, or the effect of cold on the skin may have like effect. Symptoms in this case can be relieved by the effect of heat or effort. Symptoms such as these can be reproduced objectively by the application of cold and can be relieved objectively by the application of heat in another area. It is surprising to note that the symptoms can be reproduced not only by the application of cold to the skin, but also by the application of cold

to an extremity even though a tourniquet be applied above the site of application in such a way as to obstruct the circulation. Likewise, relief can be obtained when produced in this way by heat applied to an extremity distal to a tourniquet which completely obstructs the circulation.

Violent gastrointestinal symptoms, therefore, can be caused by an agent of such minor importance as a sense of heat or a sense of cold, and can be relieved by the opposite sense.

The cases just described are quite different from the so-called contact group of cases of physical effects referred to previously. In the contact case of reaction, the reaction occurs only at the site of contact with the agent unless the application is so gross as to cause a general reaction. I have observed 2 patients who showed marked sensitiveness to cold who would have marked swelling of the lips, esophagus, and abdominal pain, nausea and vomiting after the ingestion of a cold drink or a cold food. In this case the effect of cold upon the skin was negative so far as the alimentary tract was concerned.

Much more can be gained in the diagnosis of gastrointestinal allergy through the agency of family history, past history, physical examination, tests with heat and cold, therapeutic tests with adrenalin and food elimination tests, than through the use of the skin tests ordinarily employed in allergic studies. These facts have been particularly emphasized recently by Rowe who has written extensively and accurately on this subject. Unfortunately skin tests in food cases are very frequently flatly negative.

Brilliant therapeutic results can be obtained in alimentary allergy through the agency of elimination diets; specific treatment in the case of sensitiveness to common foods (such as milk, eggs, or pork) which are difficult to avoid; and through the use of symptomatic remedies, especially adrenalin, ephedrine, atropine, and the salicylates. In the case of physical

allergy, much can be gained through avoidance of undue exposure to the physical agent which causes reaction and through the agency of increasing a patient's tolerance by repeated gradually increasing exposure to the agent responsible for the illness.

#### SUMMARY AND CONCLUSION

Allergy is important in relation to the gastrointestinal tract in that disturbances caused by allergy can simulate organic and functional disease due to other causes and also through causing edema of the tissues, muscle contraction, and anomalies in secretion, can actually precipitate organic disease.

Allergy in the gastrointestinal tract is more commonly caused by foods than by drugs, sera, insects, and parasites. A reaction similar in every sense to those caused by foods or other material agents can be caused by sensitiveness to the effect of heat and effort or to the effect of cold. Pollen, epidermal substances, dust, smoke, volatile oils, etc., which commonly cause nasal and bronchial symptoms are rarely absorbed in sufficient quantities to produce reaction in the gastrointestinal tract.

The diagnosis of gastrointestinal allergy can be made with relative certainty.

Treatment of the condition is likely to be brilliantly successful if correctly diagnosed.





# MANAGEMENT OF GASTRIC AND DUODENAL ULCER

## WITH SPECIAL REFERENCE TO INDICATIONS FOR MEDICAL AND SURGICAL TREATMENT\*

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ONE of the greatest problems in the treatment of gastric or duodenal ulcer is to determine whether medical or surgical treatment is indicated.

If I had an ulcer of the stomach of not too long standing and there were no surgical complications, such as perforation, pyloric obstruction or repeated hemorrhages, I should certainly elect medical treatment. With rest and the Sippy regimen, the chances of ultimate recovery would probably be from 80 to 90 per cent in my favor.

On the other hand, if there were repeated hemorrhages or the evidence showed location of the ulcer in the duodenum, it would be time to consider a gastroenterostomy. If persistent pyloric obstruction developed, this operation would certainly be indicated. And, if symptoms recurred on slight provocation after correct medical treatment, it would again be time to consult the surgeon.

These factors are but a few of the many intricacies that make peptic ulcer one of the most difficult diseases to treat satisfactorily and justify a reconsideration of the whole subject.

### LOCATION OF PEPTIC ULCERS

For practical purposes of diagnosis and therapy, gastric, duodenal and gastrojejunal, or marginal, ulcers may be classed together. Their symptoms and modes of treatment are so nearly similar that we may think of them under the term "peptic ulcers."

It is seldom that ulcers are found exactly at the pylorus. Gastric ulcers are usually located 2 in. or more from the pylorus, while duodenal ulcers as a rule occur  $\frac{1}{2}$  in. or more from the dividing point between

the stomach and duodenum. Jejunal ulcers, also termed marginal or gastroenterostomy ulcers, appear along the stoma produced by gastroenterostomy.

As to duration, peptic ulcers may be classed as acute, subacute or chronic. They may be simple, perforating or indurated. Multiple ulceration may occur.

### INCIDENCE OF OCCURRENCE

In frequency of occurrence, it has been estimated that from 60 to 80 per cent of peptic ulcers are duodenal, with the greater incidence in the male sex. In women the duodenum has a more transverse position, permitting better neutralization of the chyme by the bile and pancreatic juice. In the female, ulceration is more frequent between the ages of twenty and thirty, while in men the more common age of occurrence is between thirty and fifty. Men suffer more frequently from chronic, indurated and perforating ulcers than do women. Jejunal ulceration follows from 2 to 10 per cent of gastroenterostomies. Rarely, have cases of ulceration in infants, as well as in aged people, been observed.

### ETIOLOGY

While various theories have been advanced regarding the causative factors giving rise to peptic ulcer, laboratory experimentation has so far failed to support the conjectures of any one group of investigators. That gastric juice has the property of digesting weakened tissue is acknowledged by all investigators. This factor leads one to the conclusion that ulceration may take place from gastric juice erosion when the mucosa has been devitalized as in anemia, nervous strain and worry. There are likewise pathologists

\* From the Department of Surgery, DeCourcy Clinic. Submitted for publication August 22, 1930.

who are of the opinion that devitalization of tissue may arise from wrong eating and irritation from alcohol and tobacco. Traumatism is sometimes causative. It is possible also that certain individuals have a constitutional deficiency which predisposes them to ulceration.

Other investigators are of the conviction that ulcer of the stomach or duodenum is due to infection from other parts of the body. Such a one is Macrae, of England, who goes so far as to maintain that all peptic ulcers are of infective origin. In my opinion, this has not been proved, though local infection may undoubtedly be considered an etiological factor. It would not appear good judgment to allow an ulcer patient to continue swallowing pus from pyorrhea pockets; but treatment of the focal infection should be considered in the nature of a prophylactic provision, rather than presumptive therapy for cure of the ulcer. Specifically, peptic ulcer may be syphilitic, tuberculous, or of actinomycotic, typhoid or anthrax origin. Occlusion of a blood vessel of the stomach or intestinal wall, as in arteriosclerosis, may give rise to ulceration. Focal infection of the tonsils, teeth, appendix or gall bladder may be considered a predisposing condition, as well as hyperacidity resulting from stricture of the pylorus.

The relationship of peptic ulcer to malignancy is likewise a question upon which there is still much divergence of opinion, with claims varying from 5 to 70 per cent of cases for chronic ulceration as causative of gastric carcinoma.

#### DIAGNOSTIC PROCEDURE

Peptic ulcer is not always easy to diagnose because of the variability of accompanying dyspeptic symptoms. However, the use of roentgenography is exceedingly valuable for accurate diagnosis. The positive findings of roentgenography show a barium-filled or bismuth-filled crater at the site of the ulcer. A persistent indentation in the outer curve of the gastric wall, opposite to and pointing

toward the crater, is a positive sign. The indentation is due to peristaltic spasm and it resists belladonna. In the stomach, the indentation may give rise to the picture known as hour-glass stomach, in which the organ appears to be composed of two chambers, which do not disappear with manipulation or use of belladonna. In chronic perforated ulcer, the roentgenogram shows an accessory, outlying pocket filled with barium or gas. Less definite roentgenographic indications are a suspicious area coinciding with a tender spot, deformity of the first portion of the duodenum, adhesions adjacent to the stomach and extreme spasticity.

A general symptom of peptic ulcer is chronic gastric disturbance of several years' duration, the attacks occurring periodically and lasting from two to six weeks. The attacks do not incapacitate the patient for work, the appetite is normal and undernourishment is not present. Epigastric pain and tenderness are present, but the pain is seldom severe and piercing.

The rhythmic appearance of the pain after a meal may serve to distinguish between stomach and duodenal ulcer. In stomach ulcer the pain occurs in the following rhythm: food-intake, period of ease, pain, then a period of ease before the next meal. The pain occurs one-quarter to two and one-half hours after meals. In duodenal ulcer, the pain, after it starts, continues until the next meal; and the rhythm of occurrence may be indicated in the following order: food-intake, period of ease, then pain until it is relieved by further food-intake. The pain usually occurs in from two to four hours after eating. Thus in duodenal ulcer one might expect occurrence of pain about eleven in the morning, four in the afternoon and in the middle of the night. The patient may be in the habit of keeping a bite to eat by his bedside for relief of the nocturnal pain.

Other general symptoms of peptic ulcer are vomiting, which may give incomplete relief from the gastric pain, and hematemesis. The presence of occult blood in the

feces or in gastric washings is strongly indicative of ulceration. Diagnosis may be furthered mechanically by the various test meals, which in ulcer usually show prolonged digestion and an excess of free and combined acid, though in a very small percentage of cases hypoacidity may be present.

#### PROGNOSIS AND DIAGNOSIS OF COMPLICATIONS

The complications most to be feared from peptic ulceration are severe hemorrhage and perforation. Duodenal hemorrhage is more dangerous than gastric hemorrhage, but is seldom fatal. It may be so severe as to cause the patient to faint, and is usually followed after twelve or more hours by offensive, tarry bowel movements. Rupture may be classified as acute perforation with diffuse peritonitis, subacute perforation with recurring localized peritonitis, and chronic perforation with localized peritonitis and adhesions.

Uncomplicated peptic ulcer is not accompanied by acute pain. With or without a history of ulcer, sudden excruciating pain so violent as to cause shock and require opiates is indicative of acute ulcerous rupture. It is accompanied by extreme rigidity of the muscles of the anterior abdominal wall, tenderness, and tenseness of the whole body to avoid pain. The patient gives evidence of agony, with pallor, brow bathed in sweat, and short, spasmodic respiration. The temperature remains normal or is slightly subnormal and the pulse, too, is normal until peritonitis complicates the picture. The pain is localized in the epigastrium, or may occur in the back, the region of the shoulder blade or the right abdomen. There is evidence of free fluid and gas in the abdomen.

A diminution in the symptoms four or more hours later presages a generalized peritonitis and death, unless immediate surgical intervention is resorted to. Operation within six hours after rupture is favorable to recovery. Operation after

thirty-six hours may lead to recovery in a minority of cases. Each hour of operative delay lessens the patient's chances of living.

Subacute and chronic perforations are not so critically dangerous as immediately to threaten life, but in the long run seldom are relieved except by operation. In subacute rupture, leakage is slow, giving rise to a localized peritonitis and adhesions. The syndrome incapacitates the patient and renewal of daily activity usually results in relapse and an eventual state of chronic perforation.

In chronic ulcerous perforation, the roentgenogram, as mentioned previously, reveals an outlying, accessory pocket or diverticulum. The patient will not be incapacitated for work, but experiences chronic pain. Multiple adhesions follow between the gastric wall and neighboring organs, and there may be some local or general peritonitis. Operative procedure is necessary for relief.

When there are symptoms of acute rupture of peptic ulcer, it is necessary to differentiate the diagnosis from that of acute appendicitis, acute hemorrhagic pancreatitis, and gallstone attack. Peptic ulcer perforation gives rise to more violent symptoms and shock than does appendicitis, and exhibits rapid influx of liquid and gas into the abdominal cavity. In pancreatitis, there is a similarity in intensity of shock, but there is less free fluid and total absence of gas in the abdominal cavity. Gallstone attack likewise does not present so severe a symptomatology, does not persist, may be relieved by vomiting, and fluid influx into the abdominal cavity is lacking.

#### MEDICAL VERSUS SURGICAL INTERVENTION

To the ever-present question whether peptic ulcers shall be treated medically or surgically, perhaps summary answer may be made in this fashion. In their early history, good judgment indicates medical treatment of peptic ulcers. If they persist or recur in spite of modern medical management, better judgment requires recourse

to exploratory and therapeutic surgery. Exploratory surgery is of prime importance when malignancy is suspected because of persistence of symptoms in spite of good ulcer management.

Serious and numerous hemorrhages which threaten life indicate surgery, as does also continued slow bleeding, obstinate to medicinals and resulting in severe anemia. Recalcitrant pyloric obstruction is best treated surgically. And, as mentioned previously, acute rupture of the ulcerated wall demands immediate surgical intervention.

#### RÉSUMÉ OF MEDICAL TREATMENTS

Medical therapy according to the regimen of Dr. Sippy has for its purpose shielding the ulcer from the corrosive effect of the gastric juice. The Sippy treatment accomplishes this by neutralizing the hydrochloric acid with frequent feedings and the use of alkalis. The patient is required to remain in bed from three to four weeks and may partake of a wide variety of soft and palatable foods. Control of acidity is accomplished by feeding every hour, or in some cases in two, three, or four-hour intervals, with administration of alkalis midway between feedings. According to this procedure, ideal conditions for the healing of the peptic ulcer are maintained when the aspirated stomach contents show absence of free hydrochloric acid during the entire time that food and secretion are present in the stomach. The regimen provides also for control of excessive night secretion of gastric juice.

The Alvarez treatment takes into consideration the economic status of the patient and the frailty of human nature in the face of heavy hospital bills and enforced absence from work. Of the Sippy treatment, Dr. Alvarez says:

The Sippy diet is not to be despised; it works; but it is too elaborate for the general practitioner and his poorer and more ignorant patients. It calls for considerable enthusiasm and training on the part of the physician, a hospital with excellent interns, and a patient

who has plenty of time and money to spend on his cure.

The Alvarez treatment aims to make available a practical course of therapy to the average physician and the average patient. The essential element of the Alvarez treatment consists in a smooth-food diet between meals, seldom any alkaline medication, curtailment of most forms of exercise except walking, and as much rest as may be dovetailed into the patient's daily occupation. A suggested course of frequent feedings is that the patient take with him to his daily work, say a mixture of a quart of milk, two eggs and a half pint of cream. The patient drinks a glassful at 10 A.M., and at 2, 4, 8 and 10 P.M. He may partake of another glassful should he wake during the night. The patient is kept on the Alvarez frequent-feeding diet six months, a year or even longer.

Closely allied with the Alvarez treatment is the Smithies so-called "physiologic rest" treatment. It aims to give the stomach as nearly absolute rest as possible, and starts with a preliminary period of rectal feeding. Dr. Smithies, like Dr. Alvarez, accomplishes his purpose by frequent feedings but limits the diet principally to diluted carbohydrates.

A course of treatment that has found wide favor in Russia is the Jarotzky milkless diet with white of egg and butter. It follows conclusions derived from accurate laboratory experimentation, and aims to give the stomach the greatest possible amount of rest, through a diet of whites of eggs without salt and fresh butter given alternately during the day. The uncooked whites of eggs have the property of fixing the free hydrochloric acid of the gastric juice and also of passing quickly through the stomach into the duodenum. Fresh butter, likewise, suppresses gastric juice secretion and accelerates emptying of the stomach.

#### SURGICAL TREATMENT

When peptic ulcer, even after thorough

medical treatment, exhibits complications or exaggeration of the severity of the symptoms or recalcitrant recurrences, recourse should be had to surgery. It should be noted that surgical intervention for gastric ulcer is an entirely different problem from surgical intervention for duodenal ulcer.

In gastric ulcer that does not respond quickly to medical measures, surgery is the treatment of choice. It is a well established fact, likewise, that in surgery for gastric ulcer, the ulcer should be removed. Also, early removal of the lesion increases the patient's chances of recovery, should the lesion prove to be malignant, for in gastric ulcer it is not possible to ascertain readily whether or not the lesion is malignant.

In duodenal ulcer, on the other hand, surgical treatment may safely be deferred until after prolonged attempts by medical therapy have failed, and usually it is not necessary to remove duodenal ulcers, as in gastric ulcer cases. However, if duodenal ulcer is giving rise to repeated hemorrhages, removal of the lesion itself is indicated.

#### CHOICE OF OPERATION

In deciding upon his course of procedure for operating in cases of peptic ulcer, the surgeon may depend upon no set rule of thumb. Rather must he have full knowledge of the various procedures open to him, of their indications and of their possible end-results. His choice of surgical procedure will also be governed according to whether the operation is for primary involvement or recurrence following apparently unsuccessful previous operations.

Let us consider first the surgeon's field of choice in primary ulceration. In gastric ulcer, good results require provision for adequate emptying of the stomach in ordinary digestion and for excision of the lesion. For small gastric ulcers of a diameter of 1 cm. or less, local excision, preferably by cautery, is indicated. It should be combined with pyloroplasty or with gastroenterostomy as the findings warrant. For

larger lesions, the surgeon will resort to partial gastrectomy, keeping in mind, however, the high risk associated with the sacrifice of large portions of the stomach.

For duodenal ulcer, gastroenterostomy is the operation of choice. Radical procedure is attended with high risk and is not recommended. A conservative gastroenterostomy has a mortality rate as low as 1 per cent or less, with excellent prospects of satisfactory recovery. Excision of duodenal ulcer with pyloroplasty may be employed as a conservative intervention, but radical operation as though the lesion were malignant is to be condemned. Complete excision is indicated when duodenal ulcer is accompanied by hemorrhage; and, when hemorrhage persists after operation, it is frequently found that another ulcer was present at operation but was undiscovered.

#### FAILURE OF SURGERY FOLLOWED BY ULCER RECURRENCE

Regardless of the type of primary operation, incidence of recurrence of peptic ulcer symptoms is not more than 6 per cent. Recurrence after pyloroplasty is rare, but pyloroplasty is not always a preferable procedure because it does not give such satisfactory results as does gastroenterostomy. Incidence of recurrence after gastroenterostomy has been reckoned as low as 2 per cent. Gastrectomy exhibits a distinctly higher probability of recurrence.

Recurrence of peptic ulcers after operation present the therapist with a problem requiring exceedingly fine distinctions. Careful analysis must differentiate the probable cause or causes of the recurrence, and further procedure must be based thereon. The factors influencing recurrence are various. Among them may be enumerated reulceration of the old lesion, development of a new lesion, or additional ulceration which was present at operation but not discovered. There is the possibility, also, of persistence of a causative dyspepsia or superimposition of causative dyspepsias that had not previously existed.

#### MODE OF TREATMENT FOR RECURRENCE AFTER OPERATION

Response to medical treatment of a recurrent peptic ulcer after operation does not result so satisfactorily as does medical treatment for primary ulcer. Consequently more recurrent ulcer patients come to operation than do primary ulcer patients. In this connection it might be interpolated that the practitioner need not hesitate to institute prolonged medical therapy in an endeavor to avoid repetition of operation, for a recurrent ulcer seldom terminates in malignancy.

Surgical procedure for recurrent ulceration after previous operations may be roughly divided into two classes, according to whether the symptoms are caused by a new lesion or by reulceration of the old lesion.

New ulceration after pyloroplasty should be excised and a secondary plastic operation or a gastroenterostomy performed. New marginal lesions involving the stomach or jejunum after a previous gastroenterostomy may be excised; and, if the primary duodenal ulcer has entirely healed without deforming the structures, the original natural pathway between stomach, pylorus and duodenum may often be satisfactorily restored. The stomach and the jejunum will in such instances be disconnected and the gastroenterostomy discontinued. Even if the original duodenal ulcer has not entirely healed, the same procedure may often be maintained, excising the duodenal lesion and reconstructing the pylorus and the duodenum. Partial gastrectomy and partial duodenectomy may be necessary in addition.

When the recurrence appears to be a reactivation of an old duodenal ulceration, especially after previous gastroenterostomy, it will usually be found that the artificial gastroenterostomy opening has not been well located, is too small and fails to function properly, though the gastroenterostomy itself does not exhibit ulceration. The best procedure is to excise such duodenal lesions, preferably

by eantery, and explore for any additional previously undiscoverable lesions on the posterior wall. Again it is frequently favorable to disconnect the stomach and the jejunum and to reconstruct the pyloric outlet and the duodenum.

In cases where old duodenal ulcers have broken out anew in spite of well chosen and properly functioning gastroenterostomy, it may be necessary to resort to a Billroth II operation and partial duodenectomy.

The most difficult problem for the therapist is recurrence of gastric ulceration after previous partial gastrectomy, for further resection is extremely unfavorable and hazardous. In recurrence following the Billroth I type of resection, gastroenterostomy may prove satisfactory. After a Billroth II type of resection, a preliminary jejunostomy may be performed, permitting a more radical secondary procedure.

#### CONCLUSIONS

Summarizing my brief exposition on peptic ulcers, I will call to mind that, after repeated trials by medical management have failed, perhaps in 10 to 12 per cent of cases, refractory peptic ulcer should be given the benefit of surgical intervention. In determining the line of treatment, it is of greatest importance that internist and surgeon collaborate to the best interests of the patient. Great patience will need to be exercised by both the patient and the therapist, for it will frequently be necessary to prolong the treatment over a period of months or even a period of years. The ease of recurrence will discourage both the patient and the practitioner. Accessory to either medical or surgical intervention will be the necessity of so re-ordering the patient's daily activity and diet as to eradicate inimical factors and to set up ideal conditions for repair and prophylaxis. Each patient will be a clinical picture unto himself, requiring searching out of particular causative factors and individual modes of treatment and limitations of habits of living.

# PARTIAL GASTRECTOMY

## IN THE HANDS OF THE GENERAL SURGEON\*

J. MINTON MEHERIN, M.D.

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IN visiting the various German clinics one finds that the prevalent opinion throughout Germany today is that both gastric and duodenal ulcer, in the face of the failure of conscientious medical treatment, is to be treated with partial gastrectomy in one of its forms. Gastroenterostomy is called upon in those cases where the patient's condition demands the simplest of procedures; where the operative difficulties would involve unwarranted risk; and in some cases of pyloric stenosis. Local resection, inversion of the ulcer, pyloroplasty and pylorectomy are seldom used.

The well-trained surgeon should be capable of doing any and all of the procedures with equal skill. His failures will not often be explained by a failure of the operative method, per se, but as an error in not choosing the appropriate method for the case. He must be capable, after a careful survey of the given pathology, of choosing correctly that method which promises for the individual case the maximum opportunity for cure with the minimum risk. To change from one operative method to another with the procedure well under way is to invite disaster.

The rules which have been adopted for the selection of method in this clinic are:

The method of Billroth 1 shall be used in all cases of ulcer lying in the region of the duodenum, pylorus and antrum in which the pathology presents no unusual difficulties to the carrying out of the procedure.

The Billroth 2 (Mikulicz-Kronlein-Reichel modification) shall be substituted for the Billroth 1 operation in ulcer lying high above the pylorus; in those cases where the freeing of the duodenum from the pancreas is beset with such difficulties as to

make it unwise to use the cut end of the duodenum in the reanastomosis with the stomach; where the lumen of the duodenum is so contracted as to warrant the fear of a later partial stenosis at the site of anastomosis; and lastly, where the reunion of the stomach and duodenum would necessarily involve tension at the suture-line.

In routine practice one-third of the stomach (antrum) with the pylorus and the adjoining portion of the duodenum has been removed. Removal of the ulcer, where possible, has been considered an essential part of the operation. Routine appendectomy has been not the rule but rather the exception.

Gastroenterostomy is done as stated here: in those cases where the patient's condition demands the simplest of procedures; where the performance of resection would involve unwarranted operative risk; and in some cases of pyloric stenosis. Gastroenterostomy with occlusion of the pylorus, because of the unhappy results experienced, has not been done during the past five years.

The series presented contains 211 patients operated upon by 11 different operators, all of whom had had a minimum intensive training of five years in this clinic before being allowed to do partial gastrectomy.

Of the 211 patients, 113 were operated upon by the method of Billroth 1; 58 by the modified Billroth 2 method; and in 40, gastroenterostomy was done, in 9 of whom pyloric occlusion after the method of von Eiselsberg was performed.<sup>7</sup>

The shortest postoperative period through which the cases have been followed is eighteen months and the longest ten years. Personal interview and re-examina-

\* From the Chirurgische Klinik und Poliklinik der Universität Halle-Wittenberg, Prof. Fritz Voelcker, Director.  
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tion were done where possible, the other cases being investigated by an exhaustive questionnaire in which space was provided for the patient to discuss his progress from the date of dismissal from the hospital up to the present day. The answers were for the most part entirely satisfactory, the replies being clear and concise. Three hundred cases were investigated, of which 89 were eliminated because of insufficient data, etc.

#### METHOD OF CLASSIFICATION OF RESULTS

One is constantly disappointed, in reading the literature on this subject, by one's inability to draw definite conclusions from many of the articles because of the multiplicity and inaccuracy of the terms used in qualifying the postoperative results. Such terms as "good results," "permanent results," "satisfactory results," etc., without further classification, convey nothing definite to the reader. If we are, in the future, to arrive at a more definite or a more unanimous opinion as to the worth of the various operative procedures about which there is such a divergence of opinion, then a stricter and preferably a standardized classification will be necessary. Perhaps with a more definite classification in use there will be fewer reports of 98 per cent of "satisfactory results."

The classification which I offer here has been taken in each of the four groups from the patient's own description of his present condition.

*Cured:* Those patients who have been followed for a period varying from eighteen months to ten years after operation and who have remained absolutely symptom-free on a general diet and who have been able to resume their former occupations.

*Greatly Improved:* Those who are on the whole symptomless but who after exhaustion or dietary indiscretion (usually alcohol) have occasional eructations and a feeling of fulness in the epigastrium.

*Improved:* Those who must avoid some of the heavier foods and who after overwork or dietary indiscretions suffer sour eructations and dull pain in the epigastrium.

*Unimproved:* Those having similar symptoms to those suffered previous to operation or in whom the symptoms are alleviated but still appear periodically. Lastly, all patients who still vomit, whether frequently or only occasionally.

#### DIET

It is fitting in judging this classification to remember that this series dates from 1919 to 1927 and that during the period from 1916 to 1925 the people as a whole were greatly undernourished and had learned to eat any and all types of food. Thus, most of the patients treated in this clinic are absolutely intractable toward the maintenance of a postoperative diet. As soon as they are dismissed from the clinic they admit returning to their former diet of sausage, brown bread, the rougher vegetables and usually beer. When, then, dietary indiscretion is voluntarily admitted, one may take it in the extreme meaning of the phrase.

#### OPERATIVE RESULTS

##### BILLROTH I

A total of 113 cases, 73 of which were of the stomach, 23 of the duodenum and 17 of the pylorus.

	Stomach (73)		Duodenum (23)		Pylorus (17)	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Group 1 cured.....	43	58	12	53	3	17
Group 2 greatly improved.....	8	11	3	13	1	5
Group 3 improved.....	10	7	4	17	7	41
Group 4 unimproved.....	12	23	4	17	6	37

After a careful consideration of the preoperative and postoperative condition of those patients falling into Group 2 it is to be concluded that they have been so much benefited, that operation, not forgetting the risk, has been justified. If then we are allowed to combine Groups 1 and 2 we see that 69 per cent of the stomach ulcers and 65 per cent of the duodenal



ulcers have been greatly benefited by operation.

"Ulcers on the pylorus" have been perforce so classified since the operator had in these cases classified an ulcer lying anywhere on the pyloric ring as "pyloric ulcer." We are aware that if one classifies these ulcers according to their relation to the pyloric vein one may seldom speak of a true pyloric ulcer. I am unable to explain the poor results obtained in the 17 cases in this group.

#### BILLROTH 2

A total of 58 cases, of which 30 were of the stomach, 25 of the duodenum and 3 of the pylorus.

	Stomach (30)		Duodenum (25)		Pylorus (3)	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Group 1 cured	18	60	13	52	2	66 $\frac{2}{3}$
Group 2 greatly improved	7	23	3	12		
Group 3 improved	2	7	6	24		
Group 4 unimproved	3	10	3	12	1	33 $\frac{1}{3}$

In combining Groups 1 and 2 as under the Billroth 1 classification, we see that 83 per cent of the stomach cases and 64 per cent of those of the duodenum have been greatly benefited by operation. The 3 cases of pyloric ulcer are self-explanatory.

#### GASTROENTEROSTOMY

Since gastroenterostomy was performed in those cases in which resection seemed contraindicated, the figures will also be given. The gastroenterostomy series is

	Stomach (9)		Duodenum (9)		Pylorus (13)	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Group 1 cured	2	22	5	55	5	38
Group 2 greatly improved	3	33	2	22	3	23
Group 3 improved	..	..	1	11	1	7
Group 4 unimproved	4	45	1	11	4	32

really too small to allow of its classification in percentage. The figures are merely so given to permit of rapid comparison with the two tables given here.

Of the nine cases of gastroenterostomy with occlusion of the pylorus after the method of von Eiselsberg,<sup>7</sup> only 3 could be classed as cured, the others being classified as unimproved.

#### MORTALITY

It is here under this heading that one who seeks guidance from the literature may dwell with the greatest profit, for the operative results in the surviving patients, even though they be 100 per cent, must be weighed against the fatalities encountered in the use of the method.

	Billroth 1	Billroth 2	Gastro-enterostomy
No. of cases operated upon	164	126	105
Deaths	15	17	5
Mortality rate	9.1%	13.8%	4.7%

#### MORTALITY STATISTICS

Cause of Death	Gastro-enterostomy	Billroth 1	Billroth 2
Pneumonia	...	5	3
Emboli	...	..	2
Shock	...	..	1
Hemorrhage	...	1	2
Ileus	1	1	
Dilatation of the stomach	...	1	
Perforated duodenal ulcer			
5 days postoperative	1		
14 days postoperative	1		
Leakage of inverted duodenal stump (peritonitis)	...	..	2
Leakage at site of anastomosis (peritonitis)	..	1	1
Fresh ulcerations (hemorrhage)	..	..	1
Peritonitis	1	4	3
Unexplained	1	2	2
Total Number of Deaths	5	15	17

(The figures here given are taken from the entire series and not alone from those cases which have been followed.)

That the Billroth 2 operation should carry a mortality rate 50 per cent higher than that of the Billroth 1 is not the experience of most. It must be considered

that according to the rules given here the Billroth 2 procedure would be used in the most difficult cases. It is striking that of the 17 deaths from this operation, 14 of these patients were operated upon for ulcers of the duodenum. It is true that the performance of the operation takes somewhat more time than that required for the Billroth 1 but this could hardly be considered a factor in our higher mortality rate since there was but 1 death which was attributable to shock. On the other hand there were 2 deaths from peritonitis arising from an ineffective inversion and consequent leakage at the suture-line of the duodenal stump. These 2 cases as well as the third case of peritonitis, which could be traced to a leakage of the suture-line between jejunum and stomach, must be charged to technical errors, since this accident should be avoidable in the Billroth 2 procedure.

The freeing of the duodenum from the pancreas in those duodenal ulcers which are firmly adherent to, or, penetrated into the pancreas, is perhaps the most hazardous step in the performance of this operation. In freeing the duodenum it is too often the case that the serosa and muscularis of its posterior wall are stripped away and the operator is confronted with the task of inverting the stump in the face of a deficiency of the serosa of the posterior wall. Under these conditions the inversion is usually inefficient and the operative risk is greatly increased.

The second danger in the freeing of the duodenum is the wounding of the head of the pancreas with the possibility that the sutures will later be digested by the pancreatic secretions.

The experienced surgeon will most often know from his initial survey of the pathology whether or not he will be able to free the duodenum from the pancreas without inviting disaster. When he is convinced that the risk incurred in so doing would be unwarranted he will be wise in completing the procedure with a more conservative operation. One is not justified,

once having started to perform a Billroth 1 and having freed the duodenum at the cost of stripping the posterior wall of serosa and muscularis, in then deciding that one must complete the procedure with the modified Billroth 2 operation.

The 1 death from peritonitis in our Billroth 1 series resulting from a leakage at the suture-line between the reunited stomach and duodenum must be somewhat more kindly regarded, since this error has been made by the best technicians and has been consequently a long-warned-of hazard.

Many have taken their stand against the operation of Billroth 1 because of the fear of postoperative dilatation of the stomach. One of the 15 deaths in our series could be ascribed to this cause and it was a worrisome postoperative complication in many of the cases.

The deaths following gastroenterostomy were less noteworthy, with the exception of the two patients who died five and fourteen days postoperatively, death being due in each case to a perforation of the duodenal ulcer.

In comparing the mortality of this series with that of several representative clinics it is to be seen that it is not excessively high. Louria<sup>8</sup> reporting the cases from von Haberer's clinic in Graz during the years 1925 to 1927 reports a general mortality of 8.4 per cent; Berg<sup>9</sup> reports an 8 per cent mortality from the Mt. Sinai Clinic; and Magazinik<sup>10</sup> reported in 1929 as a result of a questionnaire sent to the various Russian surgeons a general mortality of 12.2 per cent in partial gastrectomy.

The point raised in the study of these statistics is that the average general surgeon must expect a mortality of 8 to 10 per cent in the use of these methods. It is to be hoped, however, that this mortality can be decreased through a greater experience in choosing the operative method most applicable to the case and in learning once and for all that ulcers which have penetrated into or are strongly adherent to the pancreas are to be regarded

with the utmost respect and should probably most often be handled with one of the more conservative operative procedures.

That the mortality rate can be cut to a minimum is shown by the results of Bastianelli<sup>11</sup> whose mortality is but 2 per cent; Moynihan<sup>12,13</sup> reports a mortality ranging from 1.6 per cent to 3 per cent during the past ten years; Finsterer in 850 resections had a mortality of 3.8 per cent and von Eiselsberg in 449 cases a mortality of 3 per cent.<sup>14,15</sup>

In the last analysis the task of relieving the patient who continues to suffer from the symptoms of chronic ulcer despite rigid medical treatment is that of the surgeon. It should be the aim of the general surgeon to offer this relief while attempting to reduce the risk associated with these operative measures.

#### COMMENT

In combining the figures of the Billroth 1 and 2 procedures it can be said that 59 per cent of the stomach ulcers have been cured and 17 per cent greatly improved; 7.5 per cent have been improved and 16.5 per cent must be classed as unimproved.

Of the duodenal ulcers, 52 per cent have been cured, 12.5 per cent greatly improved, 21 per cent improved and 14.5 per cent remain unimproved. The end-results of the comparative figures of the Billroth 1 and 2 procedures may, in such a small series, be looked upon as quite the same but the half again higher mortality of the Billroth 2 operation overrides all other claims in this series.

It is to be seen that the results in this series are not to be compared with those published by surgeons having a very much larger material and doing the entire operating themselves. Finsterer<sup>14</sup> in a series of 850 cases reports 97 to 98 per cent as cured; de Takats,<sup>16</sup> 226 cases with 84 per cent cured and von Haberer in his carefully followed series of 2310 stomach resections reports but 0.6 per cent of recurrent ulcers.<sup>17</sup>

It is, of course, to be taken for granted

that by and large the surgeon with the greatest experience will obtain the best results. The point in question is: What results may the well-trained surgeon working with a comparatively small material hope to obtain? I think that our statistics answer this in part.

Is the general surgeon justified in continuing to perform partial gastrectomy with its average mortality of 8 to 10 per cent balanced against 70 to 75 per cent positive results? I think that we have profited greatly from our previous mistakes and that the ideal set for us by those whose results have been so brilliant is within reach.

We must seek a decrease of the mortality rate in the conquest of our previous technical errors. The root of these has perhaps not been a lack of technical training but rather a failure in judgment. One must be able after a survey of the given pathology to choose with decision and accuracy the most applicable method to be used in its eradication.

In approaching the ulcers of the duodenum which are strongly adherent to or which have penetrated into the pancreas we must shackle our courage and handle them by the conservative method advised by Wilkie<sup>18</sup> and Moynihan. If resection is thought necessary it is then perhaps wiser to leave the ulcer untouched. Finsterer<sup>19</sup> has reported 53 cases followed for from two to twelve years, with 88 per cent healing, the operation of Billroth 2 having been performed and the ulcer left undisturbed. Flörcken<sup>20</sup> reports 104 cases followed for from five to seven years with 90 per cent healing in which radical removal of the ulcer was impossible but in which cases the modified Billroth 2 procedure was carried out. In truth, to know one's limitations is to defeat failure.

One must question if our results would have been better had routine appendectomy been done. This would be answered in the affirmative in most of the American and English clinics but with very much less enthusiasm in most of the German and Austrian.

It is the opinion of most that the maximum results are only obtained when a strict diet is followed for from six to nine months after operation. It is probable that had this been possible our total number of cured cases would have been greater.

In conclusion it may be stated that no matter what type of resection one may choose to do, that type must fit the given case better than any other one. I believe that the rule for the selection of method given here and used in this clinic is as good as any which we at present know, if we add thereto, that ulcers of the duodenum which are strongly adherent to or penetrating into the pancreas are to be treated by conservative surgery.

A point to be stressed is that the Billroth 2 (Mikulicz-Kronlein-Reichel) operation is not to be considered the step-brother and to be selected at the last minute because of the unlikelihood of completing the procedure with the contemplated Billroth 1. It is at this stage that failure of judgment is escorted by technical error.

#### SUMMARY

1. One hundred seventy-one cases of patients having ulcer of the stomach or duodenum operated upon by the method of Billroth 1 or the modification of Billroth 2 (Mikulicz-Kronlein-Reichel) are presented.

2. Of 113 patients operated upon by the method of Billroth 1, 73 cases were of the stomach (antrum), 23 of the duodenum, and 17 of the pylorus. In those ulcers of the stomach 58 per cent were classified as cured, 11 per cent as greatly improved and 12 per cent as unimproved; the remaining 19 per cent lying between the two latter groups. In the duodenal ulcers, 52 per cent could be classed as cured, 13 per cent as greatly improved, 17 per cent as improved and 17 per cent as unimproved.

3. The mortality rate in the Billroth 1 operation was 9.1 per cent.

4. Of 58 patients operated upon by the modified Billroth 2 procedure, 30 cases

were of the stomach, 25 of the duodenum, and 3 of the pylorus. In those ulcers of the stomach, 60 per cent were classed as cured, 23 per cent as greatly improved, 7 per cent as improved, and 10 per cent as unimproved. In the duodenal ulcers, 52 per cent were classified as cured, 12 per cent as greatly improved, 24 per cent as improved and 12 per cent as unimproved.

5. The mortality rate in the modified Billroth 2 operation was 13.8 per cent. Of the 17 deaths 14 were operated on for ulcer of the duodenum.

6. The results obtained in ulcer of the stomach with the modified Billroth 2 operation were somewhat better than those obtained with the Billroth 1, but in this small series one could in general say that there is little to choose in the end-results of the two methods.

7. The figures from a small series of gastroenterostomies are given. It is worthy of note that of the 5 deaths in 105 cases 2 were attributable to perforation of the duodenal ulcer on the fifth and fourteenth postoperative day.

8. Gastroenterostomy with the occlusion of the pylorus after the method of von Eiselsberg has given unhappy results.

9. The rules followed in this clinic for the selection of the operative method are given.

10. Ulcers of the duodenum which are strongly adherent to or have penetrated into the pancreas are to be operated upon conservatively.

11. Billroth 1 and Billroth 2 are to be considered as two entirely different operations, each having its definite indications. They are not to be used interchangeably or the one substituted for the other with the operative procedure well under way.

12. The results obtained by the general surgeon will only show improvement after he has thoroughly learned to fit the operative procedure to the pathology and to respect ulcers of the duodenum which have become adherent to the pancreas as carrying the highest operative risk.

[For References See p. 313.]

## MESENTERIC THROMBOSIS

REPORT OF AN UNUSUAL CASE, FROM AN ETIOLOGICAL STANDPOINT\*

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THE reason for reporting this case is its peculiar cause.

Private First Class H. W. P. 64th Coast Artillery, was admitted to Tripler General Hospital, 11:45 P. M. Saturday, December 7, 1929, complaining of considerable abdominal pain. Suspected appendicitis was ruled out. An enema was given, which caused vomiting followed by relief. A previous admission in November 1929, with similar symptoms, is recorded, and relief after treatment.

Tuesday, December 11, patient went to Dental Clinic and had a tooth extracted. Following this, patient was seized by a violent cramping, abdominal pain, right side. He got out of chair and doubled up on floor, complaining bitterly of his pain. The urologist was called and immediately catheterized the ureters and did a pyelogram, which showed both kidneys and ureters as normal. Patient complained of a sticking sensation in his abdomen while on floor at Dental Clinic.

I was asked to see patient about noon by the Chief of Medical Service, Major William C. Whitmore, Medical Corps, and we made a diagnosis of suspected mesenteric thrombosis and advised immediate exploration. A mid-right rectus incision revealed an excessive peritoneal fluid, blood tinged. The ileum was dark blue and its mesentery intensively red and congested; there was no notable distention of bowel, the thrombotic mesentery and intestine supplied extended from the ileocecal valve for about 6 or 7 ft. up toward jejunum. The cecum showed marked congestion of lymph vessels.

The bowel was brought out of the peritoneal cavity and carefully examined by stripping it through the fingers, when at its upper level my glove caught on a foreign body, and examination showed two small pieces of fine wire 1 in. and 1½ in. long, respectively. These were removed from the mesentery about 1½ cm. from the attachment to bowel. One piece apparently passed through a branch of the vasa intestinal tenuis and caused the thrombosis.

The wire was very fine, about the size used in window screening. The patient has no recollection of holding wire in his mouth. It is not a dental broach or the needle wire from a hypodermic.

The conclusion is that the wire was swallowed with his food. This caused some gastrointestinal disturbance during his November admission and again in December. The sticking sensation December 11 was caused when the wire left the intestine and pierced the mesentery and the intense abdominal angina, when the actual thrombosis occurred.

After stripping bowel through fingers, its color improved and it was then returned to peritoneal cavity.

The patient made an uneventful recovery.

Note: "A case reported by J. M. Black, F.R.C.S., *Brit. M. J.*, December 28, 1929 in which a piece of wire two (2) inches long perforated the ileum. Symptoms: pain. A diagnosis of appendicitis made—explored and wire removed. Omentum had closed over wire at site of perforation."

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# THE TREATMENT OF INTESTINAL PARASITISM

## BY INTRADUODENAL INSTILLATIONS\*

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WITHIN a very short period following the introduction of the duodenal tube into clinical practice, attention was directed to its use as a means for administering medication and for the therapeutic irrigation of the small bowel. The earliest step in the process of intubating the duodenum must be credited to Hemmeter, though Einhorn in 1910 was the first to succeed in perfecting the instrument and the technique for practical clinical purposes. The earlier pioneers in the field were primarily interested in the diagnostic side, chiefly in securing the contents of the upper intestinal tract for more careful study and analysis.

In 1911, Gross called *particular* attention to the therapeutic possibilities of the new method, having interested himself in the question of lavage of the duodenum in cases of chronic duodenal catarrh, cholelithiasis, and persistent icterus. For this purpose he employed solutions of Carlsbad salts and of bismuth subnitrate, and claimed to have observed beneficial results.

Harvey Beck, approximately a year later, recorded the administration of powdered ipecac root held in watery suspension or in emulsion, by way of the upper intestinal tract through the agency of the duodenal tube. Seven intractable cases of chronic entamebic dysentery were reported to have been successfully treated in this manner.

M. Ernest Jutte, later in 1912, pioneered the idea of transintestinal lavage by means of massive amounts of fluid introduced through a slightly modified duodenal tube. The solution employed for the purpose consisted of a definite hypertonic saline mixture, which escaped absorption along the intestinal tract, and was

thus more productive of complete flushing of the intestinal contents than was effected by former methods. Further contributions from the same author supplemented his earlier views on the subject and led to suggestions for a wider application of the plan. In the last article on the subject published by Jutte in 1917, he made note of the possible value of transintestinal irrigations for ridding the intestinal tract of worms and other animal parasites. This same idea, had, however, been brought forward previously by Paleski in 1915. In discussing the therapeutic indications of transduodenal lavage, he stated that the measure should prove an extremely valuable one in the treatment of intestinal worms or intestinal parasitic diseases, using the irrigating salt solution as a vehicle for medicinal substances to bring them into close contact with the unfriendly host in the intestinal canal, at the same time causing their expulsion by the thorough intestinal irrigation.

As a further stepping stone toward the development of the idea of the relationship of duodenal intubation to the treatment of intestinal parasitism, Hemmeter in the course of an exhaustive résumé of the subject of *Giardia intestinalis* presented before this Society in 1920, entered into a detailed description of the treatment of this intractable upper intestinal infestation by means of intraduodenal medication. At this time Hemmeter drew attention to the great difficulties experienced in overcoming *Giardia* infestation which he ascribed to the migration of the organisms into the crypts of the intestinal glands as well as into the bile ducts and gall bladder. Agents designed for the destruction of this type of protozoal infection, therefore, must act not only

\* Read at the Thirty-third Annual Meeting of the American Gastro-Enterological Association, Atlantic City, May 5 and 6, 1930.

locally but likewise by absorption into the general circulation. Hcmmeter believed that hexamethylenamine might meet this indication as an antiparasitic drug since formaldehyde could be detected by him in the bile shortly following its absorption into the portal system. In other more refractory cases, methylene blue (50 c.c. of 0.5 per cent solution) was suggested, likewise, by administration through the duodenal tube because of the penetrating effect of the dye in the tissues, as well as its destructive action upon giardia in vivo.

In 1921 the writer himself published an apparently successful clinical result in a case of intestinal giardiasis by massive transduodenal irrigations with Jutte solution upon ten successive days. There was, however, a subsequent reappearance of the infection in this case, and since failure was also recorded in the use of hexelthyamine and methylene blue in a series of further observations, the intraduodenal instillation of 6 to 9 dg. of arsphenamine dissolved in 90 c.c. of water was attempted. More successful results seemed to follow this procedure, which was made the basis of a further report by me in 1922. I might add further at this time that subsequent experiences in other cases of Giardial infection have rather confirmed the early optimism recorded with this method. The destructive action of arsphenamine upon Giardia was first described by Yamanorff in 1917 in experiments upon mice, and was afterwards confirmed by Carr and Chandler in a series of human cases. The latter authors gave 6 gm. doses of the drug for four successive intravenous injections each five days apart. Kantor in 1923 stressed the important fact that salvarsan and other arsenicals are excreted mainly through the intestinal glands and biliary tract and recommended arsphenamine per rectum as well as intravenously for giardial infections. Subsequent writers, including both Chandler and Kantor, have pointed to the importance of employing a sufficiently large dosage of the arsenical preparations, since otherwise tolerance to the drug is

readily established by the organisms. Hollander found intravenous injections of arsphenamine (dose not given) unsuccessful in 2 cases reported by him, but achieved a cure in a third case by alternating the intravenous injections with duodenal lavage of 25 per cent solutions of magnesium sulphate. Lyons also commended the combination of the usual duodenal douches of magnesium sulphate with intravenous injections of arsphenamine in giardiasis, because of the association noted by him between this type of protozoal infection and gall tract disease. He advised caution, however, in judging cures of giardia infection prematurely because of the well known tendency to relapse.

A further interesting contribution to the general subject of the therapeutics of intestinal parasitism by intraduodenal irrigations was made by Rivas in 1926. Both protozoal and metazoal parasites in the human intestinal tract, according to Rivas, are subject to destruction when exposed, for a comparatively brief period, to temperatures ranging from 45 to 47°C. The detrimental effect of even slight alterations in temperature may be observed not only upon the life cycle of certain types of bacteria, as tubercle and anthrax bacilli, but upon protozoal organisms, worms and other forms of animal life as well. The plan suggested by Rivas for the more or less complete destruction and removal of parasitic infestation of the intestinal tract involves the introduction through the duodenal tube of a liter or two of normal saline solution with a temperature reading as high as 47°C. The importance assigned to the relatively high temperature of the solution is stressed above that of the effect of the flushing out of the organisms with the large amount of fluid employed. It is necessary that the parasites within the lumen of the bowel be exposed to the increase in temperature for a period of not less than ten minutes. For this reason, those organisms having their habitat within the large bowel are to be reached principally by colonic flushings



preferably in combination with instillations from above. As a further part of the technique employed by Rivas, 2 or 3 oz. of a 30 per cent solution of magnesium sulphate are introduced into the duodenum prior to the use of the heated saline solution, and this is to be repeated once or twice during the process of the flushing in order to insure more prompt evacuation from the bowel. The 234 cases of intestinal parasitism reported to have been successfully treated by the author with this thermal method were classified by him as follows: *Entameba histolytica*, 103; *Oxyuris vermicularis*, 21; *Trichocephalus*, 6; *Giardia*, 13; *Trichomonas*, 9; tapeworm, 23; hookworm, 56; and *Trichina*, 3.

Hall and Shillinger in an experimental study upon dogs with the Rivas' plan found that temperatures of 52° to 47°C. resulted in a very high percentage of removal of the infecting worms, but one-half of the dogs died within two days, showing evidence of necrosis of the intestinal mucosa. These writers suggest, therefore, that the temperature of the solution within the duodenum, should not exceed 45°C. and that the total amount of solution employed not reach above 8 l. With these precautions, they believe that the plan should prove entirely safe with the human host as well as in lower animals, and should show marked efficacy in removing worms, especially where anthelmintic drugs have been found to be of little value.

From this brief résumé of historical data, it will be seen that the trend of thought in reference to the elimination of animal parasites from the human intestinal tract has undergone some very definite and progressive changes. The fundamental principles underlying the selection of successful measures for the removal of the offending parasites, according to present day standards, should include first, safety to the host; second, the maximal destruction effect of the selected plan upon the parasite either by direct local action or by absorption into the blood stream as is necessary in some

instances; third, the rapid expulsion from the intestinal tract of the dead or stunned parasites before reinfection might take place.

As a group, the parasites infesting the intestinal tract have always proved more or less defiant to the various agencies directed toward their destruction and removal. While a few are acknowledged to be subject to complete eradication by certain specific drugs, many still remain refractory to all known methods of procedure. The *Entamoeba histolyticae*, though deeply imbedded in the tissues, are nevertheless destroyed by the specific action of ipecac and its derivatives, but this drug has practically no effect upon other intestinal parasites. Hookworm infection may be removed effectively by the use of oil of chenopodium and certain carbon derivatives, chiefly carbon tetrachloride, chloroform, and tetrachlorethylene. These drugs are also found to be useful in other of the nematode infections, but not to the same degree as is the case with the hookworm. Santonin possesses definite value in its effect upon *Ascaris*, and to a lesser degree upon *Oxyuris vermicularis*. Under certain ideal conditions of administration, the various teniae are susceptible to the stupefying action of such drugs as pelletierine and male fern, but expulsion from the intestinal canal must be fairly rapid.

This constitutes the sum total of the proved efficiency of drug therapy upon intestinal parasites, both protozoal and metazoal, as established by modern day knowledge. Chandler and Chopra state the case succinctly in reference to the intestinal worms by observing that, "Hookworms and their allies, *Ascarids* and flukes alone are fairly susceptible to therapeutic agents, tapeworms are only moderately susceptible, and *Oxyurids*, *Strongyloides*, *Trichuris* and others still hold out a large extent against all efforts to dislodge them." Furthermore, among the protozoal group, excluding the amebicidal action of ipecac, specific measures of control are still lacking



in the case of *Balantidium coli*, as well as with the many species of flagellates with the possible exception of *Giardia intestinalis*.

Doubt is still expressed by some authorities in regard to the necessity of removing certain of the intestinal parasites. The baneful influence exerted by the parasites upon their host assumes many forms and varies, of course, with the type of the invading organism, as well as with the susceptibility of the individual. Some are universally acknowledged to be frankly pathogenic, as for example, *Entamoeba histolyticae*, *Balantidium coli*, and hookworm. A considerable question still exists, however, in many sources in reference to the pathogenic possibilities of other of the parasites. The supposedly non-pathogenic group includes even such a highly motile and migrating flagellate as the *Giardia*, also the *Strongyloides*, which buries itself resistantly below the bowel mucosa, the *Ascaris*, *Oxyuris*, and *Trichuris* all of which are tissue burrowers and to a certain degree bloodsuckers. The belief in the harmlessness of many of the parasites is in great degree based upon their general prevalence without apparent clinical symptoms. This condition exists, however, in the case of parasites unquestionably accepted as pathogenic. Caldwell and Caldwell state that the difference is one of degree and not of kind, as witness, the large proportion of people infected with hookworm who do not exhibit measurable symptoms. The same is true of *Entamoeba histolyticae* infections, since it is known that approximately 9 per cent of the world's population are infested with this organism without presenting definite clinical manifestations. Furthermore, the fact must be recognized that parasitic infection exists in connection with other and in many instances more serious organic disease but none the less this does not prove the harmlessness or the innocence of the invaders. After study and observation of intestinal parasitism in its many phases over a course of years, I am myself convinced that all intestinal parasites are either definitely

or potentially pathogenic, some of course to a greater degree than others. Moreover, the presence of these foreign invaders should in each instance call for steps for their prompt removal.

The duodenal tube, I believe, has come to occupy a definite place among the means at our disposal for assisting in the crusade against these lowly offenders. Since rapid expulsion of the organisms constitutes one of the fundamental principles in antiparasitic therapy, transduodenal irrigation unquestionably offers a most valuable means to that end. The author has, during the past two years, experimented extensively with the Rivas, thermal plan. Instead of the normal saline intraintestinal flush as advocated by Rivas in conjunction with magnesium sulphate installations, I have substituted hypertonic irrigations heated to temperatures not exceeding 45°C. No untoward effects have been noted in any of the cases. The amount for each administration has averaged 1000 c.c. and in no instance has been allowed to exceed 2 l. Protozoal organisms because of their tendency to penetrate or migrate into the deeper recesses of the bowel wall, are probably never completely eradicated by this method, certainly not in my experience. There is no doubt, however, that those parasites lying free within the intestinal lumen can be, to a great extent at least, washed out by the Rivas' method. In the case of worm and fluke infections, as confirmed by Hall and Schillinger's experiments in dogs, a large percentage of the infecting organisms can be killed and removed by vigorous thermal irrigations. Nevertheless, when one considers the grappling action by means of which the heads of the various nematodes and cestodes affix themselves to the intestinal mucosa, it is not reasonable to suppose that surface washings may always suffice. In our experience with *Trichuris* and *Strongyloides*, for example, many of the worms were washed out; but a renewal of the infections appeared subsequently. However, two of the *Strongyloide* cases

have shown no trace of larvae in the feces after a period of ten and eight months respectively. In several cases of oxyuris infestation no evidence of the worms has been found after a prolonged and apparently sufficient lapse of time. A combination when possible of the destructive and stupefying effect of drug therapy in conjunction with transduodenal flushing is to be looked upon as the more ideal plan. The drugs themselves, it should be remembered, may be administered to the patient directly through the duodenal tube instead of by mouth. As stated previously, the author has found the intraduodenal administration of Arsphenamine more effective upon giardial infections than when employed by the intravenous route, as advocated by others. Furthermore, Kantor has succeeded with the introduction of oil of chenopodium in a dosage of 2 c.c. through the duodenal tube in cases of hookworm infection. Under proper precautions, there seems to be no reason why carbon tetrachloride might not be administered in a similar manner either alone or in combination with the oil of chenopodium. The way has thus been opened for what would appear to be a more effective means of administering other drugs by the duodenal route. Certainly, the expulsion of the parasites following the inhibiting effect of the specific drug can be greatly promoted by the combined employment of large amounts of irrigating fluids through the agency of the duodenal tube.

#### DISCUSSION

DR. SMITHIES: One must not forget that these protozoa infest the biliary tract, and they are *not* so harmless as some physicians would like to have us believe they are.

We have reported 36 cases of infestation of

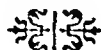
the biliary tract containing protozoa and in 14 of these we secured operative proof.

DR. MORRISON: I was very much interested in Dr. Simon's paper, because it stresses the usefulness of the duodenal tube. In 1922, Drs. Wiest and Gantt, who were then in our clinic at the University of Maryland reported a number of cases of tapeworm treated effectively by the administration of Oleoresin of male fern mixed with mucilage of acacia through the duodenal tube. We have also successfully treated cases of lamblia infection and amebic dysentery by instilling directly into the duodenum through the tube neoarsphenamine according to Dr. Simon's method and powdered ipecac respectively as advocated by Beek.

DR. SIMON (*closing*): I did not have opportunity in reading the paper to stress one important point, namely, that one or two installations of arsphenamine do not suffice in the treatment of the giardial cases. We have been in the habit of distributing the treatments a week apart and continuing them over a period of from six to eight treatments.

In reference to the use of arsphenamine intraduodenally, an advantage is noted in that there is no upset or other constitutional effect, such as is met with by the intravenous route at times. In cases of Strongyloid infection, the behavior of the worm is somewhat different from that of other nematodes. The adult Strongyloid, always female, buries itself within the wall of the small intestine, depositing the eggs into the lumen of the gut. These hatch out, producing the well known rhabdiform larvae, but the adult worm is rarely seen. In hookworm infection, on the other hand, the eggs rarely hatch within the original host, and the adult worms are much more susceptible to the stupefying effects of drugs and may be washed out of the intestinal tract more readily than is the case with Strongyloides.

The Rivas' plan should be carried out with caution, because superheated solutions are not without untoward effect upon the intestinal mucosa.



# RESECTION OF THE KIDNEY\*

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AT the beginning of the great renaissance of surgery which followed the discovery of anesthesia and



FIG. 1. Case 1. Three shadows in right kidney region.

antiseptics, many new fields were opened up and surgeons had to learn by experience what was good and what was bad. It was most natural to imagine that, if disease involved one portion of a vital organ like the kidney, resection of that portion was the best procedure. Nephrectomy itself was a rare operation, and must have seemed very radical. As a result, beginning with Czerny in 1887 portions of the kidney were removed for many different conditions, including stone, hydronephrosis, tumor, tuberculosis, echinococcus, etc. In the early part of this century, Küster was able to review 30 cases. The results were in great part bad, and these bad results were due to faulty knowledge, either of anatomy or of pathology.

In a few cases it was not realized that the arteries of the kidneys do not anasto-

mose, and portions were removed in such a way that other portions had their blood supply cut off and became necrotic.

Unfamiliarity with the pathology of the kidney was a much more prolific cause of failure. Tuberculous lesions in particular tempted surgeons to resection, but experience soon taught them that the disease often involved portions of the kidney which appeared normal to the naked eye and that nephrectomy was the only suitable procedure. It was also found that neoplasms, apparently of a size suitable for resection, not infrequently had already sent out intrapelvic or intravenous projections which made anything short of nephrectomy impracticable. Among operations for the relief of hydronephrosis resections were recommended both of portions of the pelvis and of portions of the entire sac including parenchyma and pelvis. These operations often failed, as they did not always take into account the necessity for the removal of the causative obstruction, or the inability of the kidney to recover after a certain degree of hydronephrotic atrophy has been reached.

Resection of the kidney, therefore, fell into disfavor, and survived in the textbooks and reference works only for the treatment of solitary benign cysts and localized traumatic lesions.

Quite recently, there has been a renewal of interest in the operation, and with it the realization that there is a very definite and important place for it. The principles underlying the proper use of resection may be expressed as follows: If there is a portion of the kidney so badly damaged that its restoration to normal cannot occur and that its removal is desirable, and if the remainder of the kidney can be shown to be healthy, and to be so located that it will be capable of normal function after the

\* From Brady Urological Institute, Johns Hopkins Hospital, Baltimore. Submitted for publication August 28, 1939.

resection, resection may be performed. If the opposite kidney is normal, it is usually not worth while to resect unless at least

infection, or a combination of the two. Many such cases have in the past been treated by nephrectomy, but the good half



FIG. 2. Case 1. Right pyelogram. Shadows concealed by pyelogram.

two-thirds of the kidney can be saved; but if the opposite kidney is for any reason insufficient, preservation of a much smaller amount of functioning renal tissue may be desirable.

Localized renal damage due to calculus provides most of the cases in which resection is being revived. The two writers who have called attention to these cases are Young<sup>1</sup> and Judd.<sup>2</sup> The surgeon is able to do more than merely remove the stone and by eliminating the damaged portion or, as Young puts it, the "stone-bearing area" of the kidney, does something positive and I believe effective to prevent recurrence, particularly desirable when the stone-bearing area is dependent and drains poorly. While resection enables one in such cases to be more radical than heretofore, in other cases it enables one to be more conservative. I refer particularly to cases of double kidney or double pelvis where one-half of the kidney is destroyed by hydronephrosis,



FIG. 3. Case 1. Picture taken at time of discharge from hospital showing one shadow in right kidney region.

should and can be saved. My third case illustrates this point. Resection enables such cases to be cured even when the opposite kidney is absent or insufficient. The removal of one-half of a horseshoe kidney also partakes of the nature of a resection, and has been successfully carried out a good many times.

In performing resection the only serious problem is that of preventing hemorrhage. Loss of blood must be avoided during the resection and hemostasis assured at the time of closure. A very careful dissection of the pedicle must be made, and the nature of the vascular supply determined. In certain double kidneys the halves have separate blood supplies. In such cases, the vessels leading to the half to be removed are simply clamped and tied. If there is a single pedicle, as is the case in most single kidneys, the vessels must be compressed during the resection. This can be done by the fingers of an assistant, or by a rubber covered intestinal clamp. Much superior, however, is the method of placing a heavy tape about the pedicle. The tape is then twisted with a clamp until the artery is just occluded.

<sup>1</sup> *Surg. Gynec. Obst.*, 38: 107-111, 1924.

<sup>2</sup> *Ann. Surg.*, 87: 458-471, 1925.

The incisions for the resection are made so that a wedge-shaped piece is removed, simplifying the closure of the kidney. Two



FIG. 4. Case 11. Shadows in left kidney region.

rows of mattress suture are placed using a blunt needle and No. 2 chromic catgut.

The ends of the outer row of sutures are tied across the incision, drawing its edges together. The pedicle is then released, and further mattress sutures can be placed if found necessary. One should remember that the mattress sutures will cause atrophy of most of the tissue lying within them so that the excision need not be too radical.

I wish to report 3 cases in which resection was carried out successfully. All three illustrate as well interesting diagnostic problems.

**CASE 1.** Man aged thirty-four. There had been a sudden onset of pain in the right kidney region, radiating after ten days to the groin and serotum and accompanied by vomiting. The day before admission there was marked urinary difficulty, which suddenly disappeared with the free passage of about a quart of urine. A few red blood cells were found in the urine, which was sterile. On ureteral catheterization, the phenolsulphonephthalein test showed 13 per cent from the left kidney and 4 per cent from the right. The right ureteral orifice was

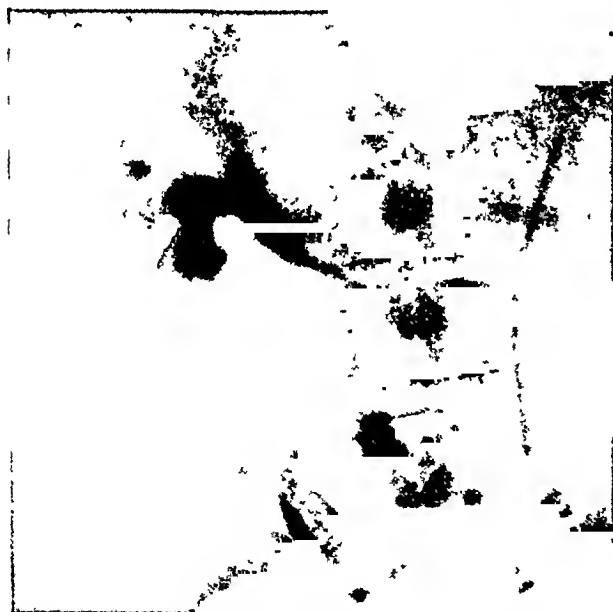


FIG. 5. Case 11. Left pyelogram, shadows are concealed by pyelogram. Stone apparently prevents sodium iodide from entering upper portion of pelvis.

They are tied moderately tight. Any tendency to cut through can be prevented by placing bits of fat and fascia under the



FIG. 6. Case 11. Small shadows still present after operation. They are probably in the gall bladder.

edematous and inflamed. X-ray showed three shadows in the right kidney region, each about 10 to 12 mm. in diameter and a small shadow

in the left kidney region (Fig. 1). The pyelogram showed the stone shadows on the right concealed by the shadow of a somewhat enlarged and irregular upper calyx while the shadow on the left was outside the renal pelvis (Fig. 2). At operation a wedge-shaped piece was removed from the upper pole of the right kidney with the idea of obliterating the enlarged upper calyx. The pedicle was controlled with twisted tape, and no difficulty was experienced with the resection, but to my surprise no stones were found even after the most thorough search with a finger inside the pelvis and the other hand outside the kidney. The closure of the kidney was accomplished easily. The convalescence was uneventful and there were no further symptoms. The discharge x-ray showed one large shadow in the region of the right kidney (Fig. 3). I believe this patient had passed a small stone and that the opacities seen were extrarenal. Efforts to learn his subsequent history have been fruitless.

**CASE II.** Man twenty-five years of age. He complained of meteorism, belching, anorexia, and pain in the left upper quadrant transmitted to the back. There were no urinary symptoms. The urine, however, showed red blood cells and a few leucocytes, but was uninfected. Gastrointestinal examination and bismuth series were negative. A plain x-ray showed a good sized angular shadow in the region of the left kidney with what appeared to be a collection of small round shadows below and external to it (Fig. 4). The phenol-sulphonephthalein output was 8 per cent from the right kidney and  $3\frac{1}{2}$  per cent from the left. The left pyeloureterogram showed the ureter rather tortuous and four dilated minor calyces in the kidney. The large stone lay in the pelvis at the ureteropelvic junction and extended into the lower calyx, which was the most dilated and which concealed the group of small shadows (Fig. 5). Resection of the lower pole was decided upon because of the supposed presence of multiple small stones which would be difficult to remove completely, and which would probably re-form in the dilated dependent calyx. The resection was completed without difficulty except that first an intestinal clamp and then an assistant's fingers failed to control the pedicle, but a twisted tape was then applied and gave very good results. The large stone was removed from the pelvis. The small stones were not seen. It was thought that they might

have been mopped out during the bleeding which occurred before the tape was applied. The closure of the kidney was satisfactory, the



FIG. 7. Case III. Diagrammatic reconstruction from x-ray plates showing atrophic right kidney, left ureter and pelvis of lower half of double kidney, dilated ectopic ureter entering urethra, and dilated upper half of left kidney.

convalescence uneventful. An x-ray taken later, however, showed the small shadows in the same place they had appeared previously (Fig. 6). Unless the stones had dropped into the depths of the wound, the shadows must represent a calcified gland or gallstones. The gastrointestinal symptoms were completely relieved according to a report received from the patient's physician several months later, and it was impossible to induce him to return to the hospital for further examination.

**CASE III.** Reported in another connection.

It was in a woman thirty-nine years of age. She complained of gradual loss of weight and strength, followed by slight fever, pain in the left kidney region, and marked pyuria. Cystoscopic examination showed the urine from both ureters clear and sterile. The right kidney pelvis was small and irregular, and the phenolsulphonephthalein excretion from this side was very low. The left pelvis appeared normal except that it occupied a low position and had only three minor calyces. Repeated research for a third ureteral orifice being unsuccessful and the patient growing worse, the left kidney was exposed and found to be a double kidney, with the upper half converted into a pyonephrotic sac. This sac was drained for three months and the patient restored to health. A pyelogram made by injecting through the drainage tube showed a large tortuous ureter extending down to a point behind the symphysis. Urethroscopy now disclosed the third ureter entering the urethra and Figure 7 is a diagram reconstructed from the various roentgenograms showing the arrangement of the pelvis and ureters. At a second operation

the upper half of the kidney was separated from the lower half at the level of a sulcus dividing them. There was some bleeding from the lower half, but not enough to require compression of the pedicle, and it was quickly controlled with two mattress sutures. The vascular supply of the upper half was so diminished owing to infection and hydronephrotic atrophy that it required no special attention, the only ligature being one around the dilated ureter. The recovery of the patient was prompt and complete. She gained 31 lb. and she has been well ever since (two and one half years). In this case resection had to be done, as the lower half of the left double kidney was performing practically the entire renal function, the right kidney being atrophied.

In conclusion, it appears from these cases that resection of the kidney is by no means extremely difficult or particularly risky. In properly selected cases it is very advantageous, and I believe should be done oftener.



COMPLICATIONS OF GONORRHEA:  
PERIURETHRAL ABSCESS, STRICTURE, ARTHRITIS\*

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THE complications of gonorrhea are so numerous and so varied that adequate consideration of all is beyond the scope of one paper. Were we aiming at completeness, we should include such widely disseminated conditions as simple balanitis, exostoses of the heel, salpingitis and gonococcus meningitis. But we have chosen rather to confine ourselves to 3 of the common complications: periurethral abscess, urethral stricture and arthritis. The statistical clinical data reported here are from the Urological Service of Bellevue Hospital.

Periurethral abscess and urethral stricture must be considered as variations of the same pathological process; periurethritis is the initial lesion in each. Following gonococcus inoculation, the infection soon involves the glands and crypts interspersed between the urethral columnar cells. Adenitis and periadenitis develop. There is swelling of the acini, leucocytic infiltration, increased mucus secretion and partial or complete obstruction of the gland ducts. Resolution without symptomatic evidence of involvement may occur; or if the infection is more severe, the inflammatory reaction intense and relatively extensive, a localized abscess promptly forms. If the abscess is small, it may be asymptomatic and discernible only by careful palpation. On the other hand, it may break its bounds, extensively involve the periurethral tissues and rupture either intraurethrally or externally.

Particularly when there is a mixed infection (streptococci, colon bacilli, anaerobic bacteria) is the development of an extensive periurethral phlegmon (so-called urinary extravasation) likely. It will be remembered that most phlegmons develop

in this manner. Although urethral stricture, obstruction or rupture are not prerequisites, one of these lesions will be found in most cases of phlegmon. Except when it directly follows traumatic urethral rupture, periurethral phlegmon or extravasation is always pathologically first a periurethral abscess.

In a recent study of 1538 urethral surgical lesions, periurethral abscess without demonstrable stricture was found in approximately 15 per cent (251). Four-fifths of these had had previous gonorrhea and we believe gonococci to be etiologically associated with the periurethral lesions. While it is usually stated that periurethral abscess is extremely common in the region of the frenum (parafrenitis of Guitterez) we found but 6 instances. In two-thirds of our cases the lesion was found in the bulbous urethra and in one-fourth either at the penoscrotal junction or anteriorly on the ventral surface. Dorsal abscesses occurred but twice. The outstanding symptoms are those of local pain with dysuria.

Periurethral abscesses which rupture externally commonly give rise to urinary fistulae. These occurred in a sixth of our cases uncomplicated by stricture. Except when generalized sepsis develops there is no evidence of functional impairment of the kidneys or architectural renal damage. In 2 fatal cases, however, the blood non-protein-nitrogen was high: 115 and 90 mg. per 100 cc. Both patients died.

The treatment of periurethral abscess depends upon the lesion itself. If there is no evidence of free pus and the lesion is not acutely painful, with skillful neglect it will usually resolve. With the subsidence of the urethritis gentle massage of the perifolliculitis against a steel sound will

\* From the Urological Service of Bellevue Hospital Read before the North Central Branch of the American Urological Association, Indianapolis, Ind., October 24, 1930.



accelerate healing. When frankly suppurative, however, incision rather than wet dressing is indicated. Only rarely will the establishment of intraurethral drainage be found satisfactory. Sometimes this can be accomplished through an endoscope.

Anatomically and pathologically abscess of Cowper's glands is a form of periurethral abscess. We found only 8 cases in this urethral series. Because Cowper's glands are confined between the 2 layers of the triangular ligament, a relatively small amount of swelling will produce great pain. As a rule, the diagnosis is easy; palpation with the index finger in the rectum and the thumb on the perineum will indicate the presence of Cowper's gland involvement. The commonest diagnostic error is the interpretation of Cowper's abscess as ischiorectal or prostatic abscess. The treatment is surgical in most cases. Extension of the abscess may terminate in intrapelvic or perineal phlegmon.

Following either surgical or non-surgical treatment of periurethral abscess, considerable periurethral sclerosis is likely to form with the ultimate development of clinical stricture. In order that stricture does not develop, it is highly important that urethral dilatation be carried on for some time following apparent cure of the abscess. In a series of 340 stricture cases which had been operated upon previously, 29 or approximately 10 per cent had been operated on for periurethral abscess. In a larger series of 1244 strictures,<sup>1</sup> periurethral abscess co-existed in 15 per cent (188). In this larger series, palpable periurethral nodules of infiltration were found in an additional 15 per cent. In other words, in nearly a third of stricture cases, palpable periurethritis exists.

It is apparent therefore, that the likelihood of stricture formation must be remembered and its preventative treatment becomes a prime consideration in the proper management of periurethral

abscess. It is indeed secondary only to evacuation of the pus.

We must now return to the pathology of gonorrheal periurethritis. Unless periurethral abscess develops, the inflammatory lesion may resolve and leave no discernible scarring or it may heal by sclerosis which ultimately becomes evident as stricture. With sclerosis a certain amount of infection is encased in the inflammatory scar and adjacent urethral glands. A vicious cycle is thus induced in which the persistent infection stimulates more scarring with stricture increase. Acute congestion from sexual excitement, the passage of instruments or alcoholism often stimulates the smouldering infection to renewed activity. This is manifested by urethral discharge, sometimes pain at the stricture site, sometimes an intensification of the urinary symptoms and not infrequently the development of an acute periurethral abscess superimposed on stricture. With more widespread periurethral involvement, phlegmon or so-called urinary extravasation develops. In a recent study of 135 cases<sup>2</sup> of periurethral phlegmon we found stricture to be the primary surgical lesion in 114. Twenty of these patients had been previously operated upon for stricture.

Renal damage secondary to stricture gives great concern in some instances. In (198) approximately 15 per cent of our stricture cases the two-hour phenolsulphonphthalein output was less than 30 per cent. In 3 cases no dye was excreted and in 4 cases but a faint trace. With the exception of the immediate treatment of the acute suppurative complications of stricture (periurethral abscess and phlegmon) the fundamental therapeutic considerations are quite identical with those of prostatism. The ultimate establishment of free drainage is the keynote of successful treatment.

It was recognized over three centuries ago by John Read that the proper management of the acute gonorrheal urethritis

<sup>1</sup> Campbell, M. F. Stricture of the male urethra. *Ann. Surg.*, 89: 379-399, 1929.

<sup>2</sup> Campbell, M. F. Periurethral phlegmon (extravasation of urine). *Surg. Gynec. Obst.*, 48: 382-389, 1929.

is the best preventative or prophylactic treatment of stricture. It is well known that the development of stricture is largely dependent on the severity and intensity of the infection but it seems to be less generally appreciated that not infrequently stricture is directly the result of improper treatment rather than the infection. Local under-treatment therefore, is preferable to over-treatment and to quote Keyes "the man behind the gun is more important than the solution of it." While most strictures are not manifest until months or years after the gonorrheal attack it should always be borne in mind that they may develop within as short a period as four weeks and, passing unrecognized, infinitely delay the cure of the urethritis. Of 714 patients who had had but one attack of gonorrhea, in approximately 4 per cent did stricture of sufficient degree to bring the patient to the hospital develop in less than one year after the onset of the infection. In about 12 per cent, a similar condition developed in less than two years. In 40 per cent, (299) the patient did not seek treatment for stricture for fifteen years or more following the infection.

The non-operative treatment of stricture is persistent and prolonged dilatation with steel sounds; we are aware that some surgeons prefer the Kollman dilator. This dilatation brings about resorption of the inflammatory exudate and will cure a few. By this method all strictures can be controlled; formed scar can be removed only by excision. As long as a stricture shows evidence of contraction it is not cured.

The site of stricture offers suggestions as how best to treat it. When at the meatus, it should always be cut. While well formed stricture of the pendulous urethra more frequently requires cutting as well as repeated dilatation, stricture of the bulb unless complicated by active periurethral infection usually responds well to dilatation alone. Strictures of the membranous urethra rarely follow gonorrhea; they are usually due to trauma. The diagnosis of

membranous stricture is difficult and because incision will probably injure the external sphincter, dilatation by sounds is the better treatment. Often impassable strictures become passable with rest and Sitz baths. If they do not, they must be cut.

Of our stricture series a third were not operated upon at the time of the first admission to the hospital. They were referred to the out-patient department where more or less continuous regular treatment by sound dilatation was carried out. Some of these showed no response to dilatation and were referred to the hospital again for operation. Therefore, failure to respond to dilatation is a definite indication for operation.

Unquestionably a great many of our patients who were operated upon might ultimately have responded satisfactorily to dilatation alone. But for economic reasons and because so many of these patients are neglectful, the immediate attainment of a maximal urethral caliber by operation seemed the wisest course. On the other hand in private practice with a more intelligent class of patients urethrotomy need be but rarely employed.

*Gonorrheal Arthritis* is the least frequent of the common complications of gonorrhea. The incidence varies from 2 to 4 per cent and most often attacks males. More recent studies have conclusively shown that contrary to older teachings gonorrheal arthritis is a polyarticular rather than monoarticular metastatic lesion; in two-thirds of our cases at Bellevue more than one joint is involved. Furthermore, a joint once involved is most likely to be the site of future arthritic lesions if urethral reinfection occurs. Trauma and unusual joint activity definitely predispose to gonococcus arthritis. In hospital practice the incidental ratio of lower to upper extremity involvement is 4 to 1. The lesion most often appears during the second or third week of the urethral infection. The symptoms of local pain and other evidence of inflammation together with

general systemic manifestations of toxemia, fever, sometimes nausea and vomiting, are well known. When arthritis occurs in association with active gonococcus urethritis the diagnosis is easy; when gonococci are not demonstrable greater diagnostic difficulties are encountered.

Our greatest interest focuses on treatment. The large variety and number of therapeutic methods advocated at once indicate that there is no thoroughly satisfactory treatment. Therapeutic attacks have been directed against the local joint lesions, against the active primary focus and also against the body as a whole. This latter method attempts to employ immunologic reaction by the injection not only of gonococcus vaccines but of other bacterial vaccines, immune serum, or foreign protein, as well as by autohemotherapy and autoserotherapy. Chemicals such as acriflavine, mercurochrome, metaphen, calcium chloride, sodium iodide and iodine (Pregl's solution) have all been used with discouraging results. Attacks against the active local infection in the urethra, prostate, and seminal vesicles have also proved inadequate. It would seem that the best immediate results have been obtained when treatment is applied directly to the involved joint. Such treatment includes immobilization with subsequent active or passive motion, heat, diathermy, roentgen-therapy and even surgical aspiration or exposure.

A short time ago Wehrbein<sup>1</sup> made a most comprehensive study in 610 cases of gonorrheal arthritis admitted to the Urological Service at Bellevue Hospital over a four-year period. During this time practically all of the aforementioned therapeutic agents were employed and the results obtained are here briefly reviewed.

A fourth of these patients received no treatment other than rest in bed, catharsis, and nourishing food. Obviously they were the milder cases; the hospitalization period averaged 7.9 days, in counter distinction

to the general average of 18.6 days of all arthritic cases. Vaccines were used in nearly half of the entire series of 610 cases, were given subcutaneously, intramuscularly and in some cases intravenously at intervals varying from three to eight days. The initial doses were small (5 to 25 million) but were gradually increased so that a few patients received as much as one billion at a time. In this series the results were unsatisfactory. Many were rendered temporarily acutely ill and a few felt somewhat improved during the three or four day convalescence from the vaccine shock. A striking vaccine immunity was obtained by many but this did not serve to cure the arthritis. Some patients who had received vaccine treatment elsewhere refused it when admitted to Bellevue.

Similar unsatisfactory results were obtained by the use of foreign protein (typhoid vaccine, casein, whole milk, fluid from the involved joint, and autogenous blood). In many cases an alarming systemic reaction occurred during which time the patient thought little of his arthritic symptoms; invariably these were again complained of in three or four days.

For intravenous chemical injection mercurochrome, metaphen, and Pregl's iodine solution were used. The injection of the latter accomplished nothing. Metaphen exhibited no therapeutic effects. Mercurochrome was given to 14 patients in 1 per cent solution, the dosage being 3 to 5 mg. per kilogram body weight. One to five injections were given each patient and while no serious permanent effects were observed, a marked generalized systemic reaction with sometimes vomiting and albuminuria occurred in a few. Mercurochrome was the only medication given which had any demonstrable beneficial effect. The hospitalization period of these cases was but one day less than the total average (eighteen days).

Direct attack on the local genital infection was of no therapeutic value. It is of interest in this connection that in 4 of the group of 30 cases treated solely by this

<sup>1</sup> Wehrbein, H. L. *Gonococcus arthritis. Surg. Gynec. Obst.*, 49: 105, 1929.

method a severe systemic reaction with high temperature followed prostatic massage. In 3 cases Pregl's iodine solution was injected into the seminal vesicles without benefit.

Therapeutic attack directed at the joint itself offers the greatest hope of symptomatic relief for the patient. In the acute stage this is best accomplished by the application of a plaster of Paris cast sufficiently snug to immobilize the joint. This method was followed in 144 patients; the casts were left on an average of ten days, were renewed in 15 cases, and in only 7 instances were joint symptoms aggravated by the splint. This latter finding suggests improper splint application with the joint in an uncomfortable state of flexion.

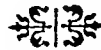
Great care should be observed that immobilization be not carried on too long as muscular atrophy and joint immobility become more marked. The best results apparently have been obtained by the use of the hot tub bath as soon as the condition of the patient will permit transportation. In the hot water active motion can usually be carried on quite painlessly, and is believed to result in fewer ankylosed joints. Unfortunately at Bellevue we have been unable to carry out this treatment. Application of heat to the joints, passive and active motion, and massage of the atrophied muscle hastens restitution to normal.

Next to joint immobilization by plaster cast, deep x-ray therapy applied to the

affected joint has afforded most prompt symptomatic relief. Twenty-two of twenty-seven patients so treated were relieved by one treatment. Only 3 were unrelieved by a series of 4 exposures. The roentgenologic effect is local and will be noted only in the joint to which it is applied. A small dose (10 to 25 per cent of skin erythema with copper and aluminum filters) is cross fired at the joint. The therapeutic action of these rays is little understood in these cases but it would seem that the endothelial, fibroblastic and leucocytic repair elements within the joints are stimulated by the relatively small therapeutic dose.

At the present time therefore, while there is no specific treatment for gonococcus arthritis, the immediate relief of local symptoms is best accomplished by splint immobilization of the joint or the application of a partial erythema dose roentgen-ray exposure. A useful joint will be rendered more likely if active or passive motion is instituted relatively early.

In a rather extensive experimental therapeutic study on the Bellevue Urological Service mercurochrome intravenously was the only therapeutic medium which by injection was found to possess any merit. Observation of the reaction following the use of this drug in many cases would, I am sure, cause one to hesitate in submitting to its use on himself. Vaccines were uniformly without therapeutic value. Rarely does joint suppuration occur and when it does, arthrotomy is usually indicated.



# FASCIA ANCHOR\*

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MANY things have been used in the past with which to tie silkworm gut, mostly with the idea of originating the fascia anchors, after I had tried many of the things heretofore mentioned.

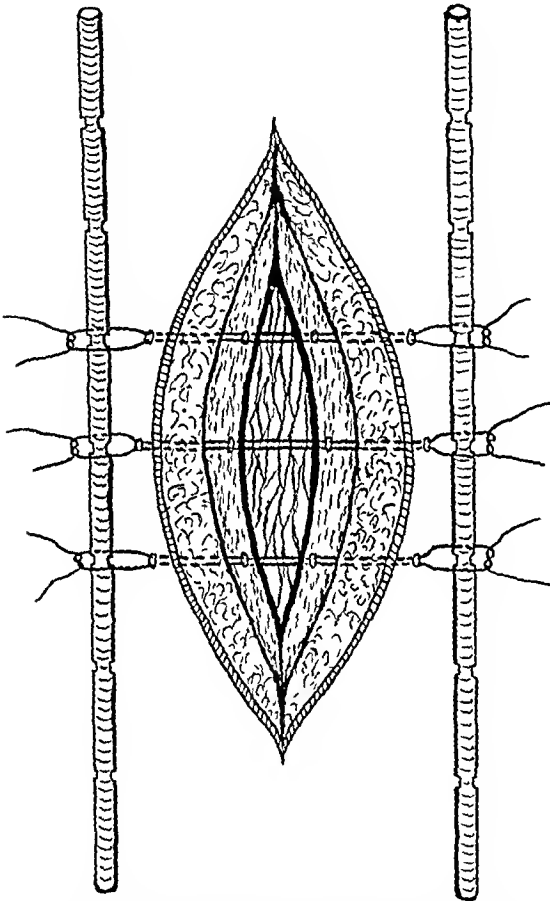


FIG. 1. Fascia anchors in position, with double strands of silkworm gut ready for tying.

preventing the cutting of skin and subcutaneous tissues, without much thought of holding in apposition and fortifying the fascia. Some of the things used have been long and short folds of gauze, buttons, dental rolls, glass rods and rubber tubing of various kinds, sizes, etc.

In my efforts in the past to prevent postoperative hernia, also to produce a narrow, well-approximated wound, with as little fibrous tissue scar as possible,

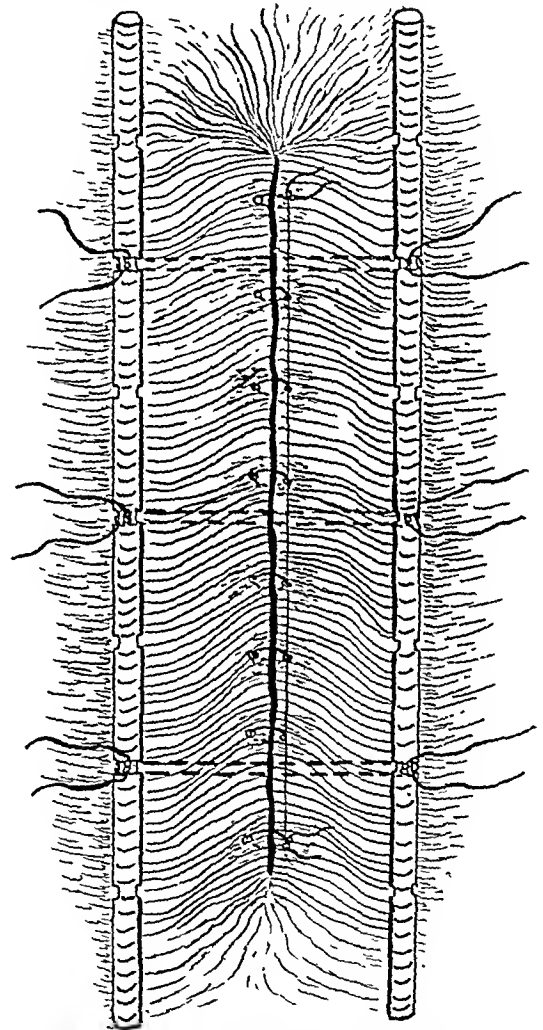


FIG. 2. Silkworm strands tied. This gives splendid apposition of incised layers with elevation.

## DESCRIPTION

The fascia anchors are made in various lengths, but those commonly used are the 10 cm., 16 cm. and 20 cm. lengths. Diameter 4 mm. They are grooved to prevent the sliding of silkworm gut, each space between grooves measuring 2 cm., and are made of rustless steel, chromed.

\* Submitted for publication October 27, 1930.

The anchors may be used to measure the size of any pathological growth, length of incision etc., as well as for fixation of silkworm gut, to bring into close apposition the fascia layer, particularly of the abdominal wall; also in the closing of a wound following a radical mastectomy and in any other part of the body where silkworm might be used.

#### ADVANTAGES

A wound is easily cared for with the fascia anchors in place and the surgeon may use any technique in cleaning wound when changing dressings, as there is no absorption of serum or purulent discharge, as in the gauze, rubber and other things used, which cause foul-smelling conditions.

The fascia anchors eliminate dead space of wounds, air bubbles, assist in hemostasis, better apposition of wounds, with less fibrous tissue scar, aid in preventing postoperative wound opening, due to strain, etc.; they also help to prevent postoperative hernia.

It is not necessary to place silkworm tight enough on fascia anchors to produce necrosis. The anchors prevent the cutting into tissue that so often occurs when tied over incision, causing discomfort to patient and aggravating the wound, increasing the tendency toward infection.

#### TECHNIQUE

There is nothing mysterious about the

use of these fascia anchors. The surgeon may use ordinary silkworm, as he does in his everyday method to close the wound,

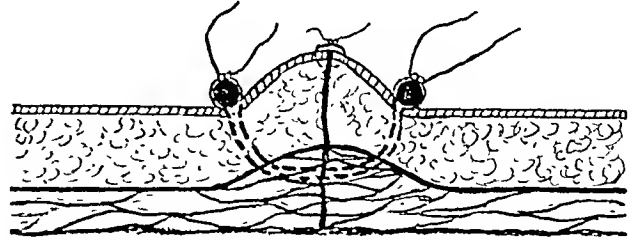


FIG. 3. Transverse section of Fig. 2. Silkworm strands pass through skin, subcutaneous tissue and fascia. Marked approximation gives less scar tissue as end-result.

using two strands in each needle, in place of one, grasping the free ends with hemostats. The fascia anchors are passed between the double strands on each side, tying one side, then the other, tying first the middle double strands, following with proximal and distal strands. If the strands are carefully tied with gentle approximation of wall layers, a splendid apposition will be brought about, with slight elevation of incision between the anchors. Gauze may be placed below each end of fascia anchors to prevent pressure, and the gauze changed with dressing by gently lifting the anchor ends with mousetooth thumb forceps or Allis clamp.

It is advisable to use the fascia anchor just a little longer than incision, as the pressure is much better equalized. Two to three centimeters are a good distance to place fascia anchors laterally to incision.



# INDICATIONS FOR EXCISION AND GASTRECTOMY AND RESULTS FOLLOWING OPERATION\*

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CHARLOTTE, N. C.

CASE 1. In July, 1917, before going into military service in September, we did a palliative gastroenterostomy, merely to relieve obstruction, in a man fifty-two years old who had been vomiting persistently, had lost over 50 lb. in weight, was pale and almost entirely exhausted. There was a mass, not only felt but seen in the epigastrium and right hypochondrium. He vomited food and barium of the day before and showed by x-ray studies a very large stomach with a little barium passing into the duodenum and an irregular outline of the antrum, a crater, the apex of which was along the lesser curvature at the pyloric canal. At operation there was a mass the size of a lemon in the antrum up to the pyloric canal, with the cap of the crater toward the lesser curvature. The exploration was quickly terminated with a gastroenterostomy. A diagnosis of cancer with metastatic lymph glands was made. The patient never vomited again, greatly improved and gained weight during three weeks in the hospital. My good-bye to him when he left the hospital was a final one and with more feeling than he ever suspected. Two years later after the war this same man, in the bloom of health and a gain of 60 lb., returned to see me, to thank me for curing him. There was no mass to be felt, x-ray studies showed a rapidly emptying stomach of normal size and the barium passed out both by the pyloric canal and gastroenterostomy opening. The man is still living and well and has paid little or no regard to his diet since three or four months following his operation.

In the light of nowadays I should have felt a confidence in his outcome, if I had considered the location of the ulcer and had made a frozen section of one of the lymph glands along the lesser curvature. Almost every surgeon I have talked to, has recited a similar surprising experience.

CASE 11. In March 19, 1924 a man aged thirty-three was rushed to the hospital on

account of having been struck with violent pain in his right upper abdomen and right side. He doubled up with severe pain and rigidity of his abdomen, which he in no way relaxed until he was under full anesthesia. This was Wednesday afternoon and he had just been dismissed from the hospital Monday after the third Sippy treatment of eight weeks each and had eaten nothing but eggs, milk and very light cereals. There was considerable fluid in the right hypochondrium and a hole nearly the size of a ten cent piece and an indurated area the size of a dollar on the anterior surface of stomach extending to the lesser curvature. There were enlarged glands along the lesser curvature. For two reasons the indurated area was excised with a cautery, first to gain more supple tissue for enfolding and second to get rid of the widespread lesion. A considerable section was thus removed and when wound was closed the antrum was very much narrowed and the pyloric canal encroached upon. With compress in the hypochondrium and change of gowns, gloves and instruments a gastroenterostomy was done. The wound healed per primam and the patient made an uneventful recovery taking a full diet in two months. He has not had the slightest complaint in over six years. Figures 1 and 2, Case 11, show the stomach during his last Sippy treatment with the ragged area located in the antrum, near the pyloric canal and a small crater continuous with the lesser curvature and four years later a narrow antrum with serrated outline along the lesser curvature. Practically all of the barium is passing through the gastroenterostomy opening.

After these resections of either gastric or duodenal ulcers with gastroenterostomy or pyloroplasty it is almost impossible to draw any conclusions from x-ray studies beyond the proper emptying of the stomach and possibly the absence of a definite crater. Compare Figure 3 of a resection of duodenal ulcer and pyloroplasty.

\*Submitted for publication December 1, 1930.



CASE III. May 21, 1924 a woman aged sixty-seven who for years suffered such violent pain and nausea on taking food, occa-

easily made through the gastrohepatic omentum, the ulcer crater separated from the pancreas, the pancreas gently cauterized and



FIG. 1. CASE II. Stomach during last of three Sippy treatments with ragged area located in antrum, near pyloric canal and small crater continuous with lesser curvature. This ulcer perforated.

sionally relieved by washing out the stomach, but as frequently requiring morphine, begged for relief by operation. She knew and was repeatedly warned that her general condition, rheumatism and leaking heart, already twice decompensated, made her operation a risk. She preferred the risk and death even, to life as it was. X-ray studies showed a collar button crater from the posterior surface of stomach in the upper part of the corpus and near the lesser curvature. This crater was a fixed point and did not shift with the movements of the stomach. The lesion did not show at all in a first series of x-rays and was only brought out on placing the patient in the oblique position (Fig. 4).

The operation was done with local anesthesia and gas. The ulcer was found on the posterior surface of the upper corpus, intimately attached to the pancreas. The fixation to the pancreas and the drag down upon it, as well as the inflammatory reaction of the ulcer evidently caused the severe pain. There were enlarged glands along the lesser curvature. Access was



FIG. 2. CASE II. Four years after cauterization and closure of ulcer and gastroenterostomy. Narrow antrum with serrated lesser curvature. Most of barium passing through gastroenterostomy opening, showing necessity of gastroenterostomy after resection of ulcer.

closed with catgut sutures. The ulcer resected and stomach closed. At this stage of the operation and without warning save for the risky heart condition, the patient's heart gave way and she died shortly after the abdominal incision was closed. Pathological section of the ulcer and gland showed no malignancy.

CASE IV. A man sixty-two years old, March 25, 1922, who had dyspepsia and colitis for twenty years. X-ray pictures taken several years previously showed gastropexia and slow motility; more recent examination of gastric contents showed absence of hydrochloric acid. There was more and more gastric distress and all foods disagreed with him. X-ray studies revealed a small stomach with feeble contraction waves, marked reduction of cavity, ragged outline of antrum along the greater



in size, still capable of accommodating themselves to the intake of a full diet and a corresponding restoration of the patients to their

tal and 5 died while in the hospital. Of the 10 treated with excision; 2 were mucosal ulcers and 1, as proved by microscopic



FIG. 5. Stomach following gastroenterostomy between duodenojejunal angle and stomach for obstruction of duodenum and stomach where emptying time is much too fast. Compare with Fig. 6.

normal weight and color. The resected stomach exhibits a motility just as vigorous as that following about 30 per cent of gastroenterostomies. Emptying time less. Compare Figures 5 and 6.

Out of 9 cases where gastrectomy was done, 7 patients are now living and well, 2 are dead after fourteen and eighteen months respectively from metastasis. Even the two patients dying of metastasis and cachexia were able to take their meals with comfort and died without any abdominal distress.

Cole reports 26 cases of ulcer of the corpus gastrica where 11 patients were treated with gastric resection, 10 with excision and 5 with gastroenterostomy without excision. Of the 11 treated with gastric resection 6 lived to leave the hospi-



FIG. 6. Stomach after gastrectomy, where more than half of the stomach was removed for carcinoma and the Pólya type of anastomosis was done. Emptying time far less than gastroenterostomy. Stomach accommodated full meals without discomfort. Compare Fig. 5.

examination, was already a healed ulcer. Of the remaining 7; 2 died, 2 were worse, 1 was improved and 2 were said to be improved. All of the 5 cases treated with gastroenterostomy lived but as we can compare each of these with a similar case treated medically without gastroenterostomy, the question arises: did the ulcer heal because of the gastroenterostomy or in spite of it. Cole's conclusions are as follows:

1. We must study each regional type of ulcer separately and therefore this communication has been confined to presentation of corpic ulcers.

2. Mucosal ulcers are so superficial and

transitory that they should not be included in a consideration of whether or not to operate.

3. If an ulcer has distorted a stomach almost beyond recognition such a distortion becomes a complication and that case is definitely surgical. No case of this character is included in the 26 cases presented herein.

4. Ulcers that occur nearer the greater curvature than the lesser should be considered ulcerations in carcinomatous areas and not benign ulcers.

5. Any ulcer that increases in size, after the initial avulsion of the crater, should be considered malignant, or at least not a single or benign type of ulcer. This increase in size must be determined by comparing roentgenograms made at the end of one week in bed, two weeks in bed, and if necessary at the end of a third week in bed, care being taken to observe that the patient is in the same posture during each examination.

6. The mortality of gastric resection for ulcers of the corpus is so extremely high that this procedure is not justified as a method of treatment for corporic ulcers.

7. Excision of a small ulcer high up on the corpus may be successful. Excision either with cautery or knife, of an ulcer near the sulcus angularis is contraindicated as it usually results in a gastric deformity requiring subsequent surgical procedure.

8. Gastroenterostomy for corporic ulcers is merely an excuse to do something. These ulcers heal in spite of the gastroenterostomy rather than because of it.

9. From an analysis of these facts, it is evident that surgical procedure is definitely contraindicated in all cases of corporic ulcer and that it should be resorted to only in such cases as are known to have gradually increased in size during a three weeks' period of rest in bed under roentgenologic control or which in that same period of time have definitely failed to diminish in size. In this latter group of cases, surgical procedure should only be resorted to, however, in the event that the symptoms are so severe that the patient demands operation. In these cases, it must be borne in mind that the same constitutional conditions which prevent the healing of ulcers, such as arterial sclerosis, make the patient an unfavorable surgical risk.

I am persuaded that Cole's observations and conclusions from the point of view of a roentgenologist are accurate and cogent

and that they can be applied practically in the determination of not only whether to operate or not but what operation to do. It seems to be a fact that almost all ulcers may be classified as corporic, prepyloric and postpyloric ulcers and that they occur in the ulcer-bearing area along the lesser curvature. Ulcers in these locations are inflammatory and not malignant. Ulcers elsewhere in the stomach, particularly near the greater curvature may be malignant and must be considered as such.

When such ulcers extend to enormous size, as they sometimes do, so as to produce lameness and obstruction of the stomach, as in the case first cited (Case 1) there is no other alternative except to give relief of obstruction by gastroenterostomy; and in an ulcer of such size the difficulty and uncertainty of determining its original location and whether or not it be malignant may be impossible. The diagnosis may be aided by a frozen section of one of the glands. Doubt as to the diagnosis may still remain and force the question of gastrectomy. It is generally accepted from experience in the hands of most operators and proved by postoperative x-ray studies that "v shaped" resection and "Sleeve" resection too frequently leave a deformed stomach with mechanical function interfered with. This is particularly true when resections are done along the lesser curvature near the sulcus angularis. In these cases, a gastrectomy is preferable. When ulcers are located outside the ulcer zone, that is, not in the antrum along the lesser curvature, excision is indicated, because of the possibilities of serious trouble inherent in the ulcer, namely perforation: (Case 11. Mr. S.; hemorrhage, Case vi., Mrs. S.; deformity with perigastric adhesions; Case iv., Mrs. Sholtz; narrowing of lumen by presence of mass and cicatricial contraction; and most important malignant degeneration; Case v. Mr. R.).

In these cases, the large obstructing ulcer at the pylorus along the lesser curva-

ture healed under gastroenterostomy; the perforated ulcer on the anterior surface of stomach under resection and gastroenterostomy; that on the posterior wall, adherent to the pancreas, was resected; in the 2 cases, one of the woman with hemorrhage and the other of the man, the ulcers were located in the antrum on the anterior wall on which gastrectomy was done. The choice between resection and gastrectomy is determined largely by the amount of the wall to be resected and the resulting deformity and interference with motor function. Where such a large area is to be resected gastrectomy is preferable; also where the ulcer is located outside "the ulcer bearing area" and where the chances of malignant changes are far greater, gastrectomy is indicated. Finally and in repetition the question of operation

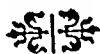
and what operation is determined as follows:

i. Ulcers of the antrum and pylorus along the lesser curvature and duodenum are benign and frequently heal under medical treatment. Dangers are perforation, hemorrhage and obstruction.

ii. Ulcers on the gastric side of the pyloric canal and outside the "ulcer bearing area" may or may not be malignant. The possibility of malignancy requires excision or gastrectomy.

iii. Excision for malignancy should be wide and extensive and should therefore be extended into gastrectomy.

iv. The function of the stomach following gastrectomy is comparable with that following gastroenterostomy and superior in every way to that following "v shaped" and "Sleeve" resections.



# STRAINS AND SPRAINS\*

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**I**N the fields of orthopedic and traumatic surgery there are two very common injuries, the strain and the sprain, which present themselves separately or together for consideration. Although these types of trauma are distinct and different entities, they are not sufficiently considered as such. In fact such injuries are unfortunately not separately identified, and the result is that the expression designating a strain or a sprain means nothing very definite by way of visualization in the minds of many.

Of course, the laity does not need to know the distinction between the entities, and they use the terms with the most vague realization of what they typify. To them, the analysis for the correct application of these terms to lesions is unnecessary. With the orthopedic and traumatic surgeon, the differences between a strain and a sprain must be fully realized. And since there are for each, separate

considerations, these entities will be somewhat fully discussed. The words, strain and sprain, are entirely too commonly considered as synonyms. They are used interchangeably when it should be realized that each should express a distinct lesion, but which is which, does not often seem worthy of the user's time to investigate. One or the other word is used very commonly at present in the hope that with the injury being considered, the word used to designate same implies everything which is found.

A strain and a sprain are two distinct lesions, which as such are very ordinarily first and often last seen by the patient or the family. Commonly either such lesion causes little concern when mentioned merely as a strain or a sprain. However, we all have seen serious consequences result, because either lesion was improperly considered as requiring experienced handling.

## DIFFERENTIATION OF STRAINS AND SPRAINS

### STRAINS

**DEFINITION:** A strain is an overstretching or an over-exertion of some part of the musculature. Strain implies a call for usage of some muscle or muscle group beyond that which normal tone has usually supplied.

**LOCATION:** Strain may be identified in any portion of the musculature. It is most commonly found in the muscles of the extremities and the back. There are no muscles, with voluntary function, which are not subject to strain. There is no bone or joint injury in strain, as such.

### SPRAINS

**DEFINITION:** A sprain is a severe wrenching or twisting of a part attached near or around a joint. It implies a resultant trauma, very commonly a fracture-tear or chipping-off of some of the bone to which the soft parts are attached. It may, however, be only the tearing of the ligamentous or tendinous structure of muscle, which is nevertheless a matter for serious consideration.

**LOCATION:** Sprain is, as the definition implies, in or around the joint. The commonest sites for sprain in their approximate order are, the ankle, fingers, wrist, knee, elbow, hip and vertebral column. It implies ordinarily a joint injury with an interruption in the continuity of ligamentous or tendinous insertions around a joint or of the bones entering in the joint.

\* Read before the North Side Medical Society. Submitted for publication December 4, 1930.

STRAINS (*Cont.*)

**SYMPTOMS OF STRAIN (Subjective):** Among athletes, in opening training or during the breaking-in period, strain manifests itself as the general muscle soreness and stiffness termed "Charlie-horse." There are as subjective symptoms, soreness, stiffness, tenderness on palpation, pain on motion, weakness and frequently swelling in the muscles involved. These disturbances do not, as a rule, manifest themselves until about twenty-four hours after the overstretching or over-exertion of the parts, and by this time they will have become very acute. They will continue so for from forty-eight to seventy-two hours in spite of all treatment, other than rest. However, at the end of this time, there follows a gradual subsidence of the symptoms, and the amelioration permits of mild function.

**Objective:** The general findings are negative for the examiner without handling of part. There are no unfavorable sequelae from unattended strain. The symptoms of strain are always gradual and sneaking with the onset, there being no history of a severe injury bringing about the same. Frequently, an unwarranted fall will cause a general evidence of strain in the non-athletic type.

**PATHOLOGY:** in case of strain is that of engorgement and congestion from over-use or overstretching of the part. This implies an increased flow to and an impeded flow from the part of the blood in the vessels supplying same. There are, consequently, distentions and rarely ruptures of the smaller or capillary vessels. Upon the discontinuance of the overstretching or over-exertion there is a readjustment of the circulation, and an arrest of further damage to the musculature is the favorable result. An edematous result, a swelling of the part occurs from the over-distention due to congestion of the vessels. The consequence of this effort is a leakage of serum from the vessels, or a possible rupture of the capillaries with hemorrhage or extravasation of blood in the area

SPRAINS (*Cont.*)

**SYMPTOMS OF SPRAIN (Subjective):** They are mild and severe. There may be an initial attack of mild shock or syncope. Nausea and vomiting are not infrequent. Sudden sharp pain around the joint involved in the injury, impaired function is at once evident. Cessation of pain during rest with a possible feeling of fulness, throbbing with tension. With efforts to movement there is stiffness of the joint involved, which increases as time goes on, with injury unattended. This is due to effusion of fluids in and around the joint.

**Objective:** Swelling is an early sign and if there is much injury to the soft parts there may be discoloration due to extravasation of blood in the tissues. There is great pain during manipulation, extensive tenderness around the entire area involved. X-ray will commonly detect a fragment, sliver, or shell of bone separated completely or incompletely from the parent bone. It should be made known to the subject at once, that unsupported or unattended sprain is a serious issue, which if let alone may become a dangerous problem. The symptoms of sprain are always acute in their onset, there being distinct history of severe trauma.

**PATHOLOGY:** of sprain is generally the same in any location. Inasmuch as there is a tear to or around the joint we should expect to find a separation or interruption of continuity or structure with extravasation of fluids, such as serum, fibrin, synovial fluid and blood, at and around the immediate location of the trauma. There is, consequently, extensive infiltration in the surrounding soft tissues with fluid, coming from the muscle fibers being swollen, some ruptured and others necrotic. The bony fragments torn from the parent bone in sprain remain attached to the over-stretched and torn ligament or tendon. From both surfaces or ends included in the tear there is effusion which becomes more abundant during use. The interstitial tissue between the muscle fibers around

## STRAINS (Cont.)

involved. A strain, rarely as such presents further serious pathology and a reestablishment of the circulation usually restores the tissues to normalcy.

**DIAGNOSIS DIFFERENTIAL:** of strain from sprain might be problematical, although it is believed that no other type of injury should easily be mistaken for it. Strain is a simple injury with no history of a serious accident or trauma to a part leading up to the incapacity. Strain occurs with sprain, dislocation, or fracture, but it is never treated separately as a complication. When it occurs alone it is a condition with no serious interruption or impairment in the continuity of structures, remains acute for several days, and disappears gradually with or without treatment.

**PROGNOSIS IN STRAINS:** always good whether treated or not. The old system of rest to the part is not generally to be advised for rapid recovery. However, in the older patients, this form of treatment, because of possible protracted favorable prognosis, is often advisable, and this is more especially the case with women.

**TREATMENT OF STRAINS:** is always meted out with a full consideration of the individual's habits. Ideally in the young, and the old of athletic tendencies, the use of the strained part should continue. This however, must be moderated with caution during the lighter normal activities. Liberal massage is very helpful, and free manipulations (active and passive) of the affected part are advised. For massage, alcohol, olive oil, witch hazel or any of the host of rubber's pet lotions or liniments may be

## SPRAINS (Cont.)

sprains shows blood stream and lymphatic activity early at work to overcome the broken part.

**DIAGNOSIS DIFFERENTIAL:** of sprain from strains, fractures and dislocation is a matter stressed by some authorities. Naturally with the history of an acute injury, strain can easily be ruled out, although it will come up commonly as a complication of sprain. A sprain is in reality a tear or fracture-tear around a joint of insufficient severity to interfere with general contour, alignment and articulations of the bones. The reality of a sprain being a severe injury develops the fact that, as a tear or fracture-tear, a sprain commonly merits fracture consideration for treatment. Sprains are diagnosed from the history of injury, the force or method producing same, the lack of change in general contour of the part injured, history of ability to use part for a time, no evidence of displacement, and general appearance of part, as well as, conduct of patient. The x-ray is very helpful with the diagnosis of sprain involving much or little of the bony structures.

**PROGNOSIS IN SPRAINS:** guarded, unless properly treated. If improperly handled severe damage, such as ankylosis, periostitis, osteoperiostitis, myositis, osteomyelitis, pressure neuritis, impairment of function and deformity may result.

**TREATMENT OF SPRAINS:** is much the same as in the treatment for fracture. Placing the part immediately at rest minimizes the severity of the symptoms. A sprain requires the placing of the part in a position which is that of over-correction with comfort to the patient. This position must be maintained by immobilization with light splintage, plaster-of-Paris being the dressing of choice. Where the severer symptoms manifest themselves, temporary splintage on a board or with any apparatus

STRAINS (*Cont.*)

used. Where there is extreme pain during the early onset of the condition, allonal or morphine will ameliorate the symptoms.

**CONVALESCENCE OF STRAINS:** is rapid with massage of the muscles involved. The early use of the affected part is to be encouraged. It should be remembered by all means that moderate normal use, although painful in the start, is safe, but further overstretching or over-exertion is ill-advised and dangerous in the prolongation of symptoms or development of complications. Light massage, active and passive movements of the muscles involved, should be the practice regardless of the age of the subject. It is not necessary to use anything by way of a lotion or liniment to lubricate or counter-irritate during massage or subsequently for dressings. The unmedicated surface may be very properly massaged and manipulated by a proficient masseur, without these. This fact is stressed because it is believed that aside from the psychic effect little value is found from the use of solutions or other preparations during a masseur's regular procedure.

**Conclusion:** This subject is not treated with anything resembling the fullness which it merits, but it is hoped that a program for liberal expression upon the consideration of the strains and sprains discussion is herewith introduced.

SPRAINS (*Cont.*)

which allows for observation of the part, without movement, is advised. The ice-bag with mild pressure may be applied in these severe cases. If heat is preferred for the comfort of the patient, it is to be applied in the dry form. After a subsidence of the symptoms, and more especially after the reduction of the swelling, the plaster cast should be applied. The part should, generally considering all parts, remain immobilized for at least 50 per cent of the time allowed for immobilization of a fracture. For periods, even up to twenty-one days, the cast may be of the continuous variety. Where a longer time for immobilization is required, the cast should be of the split or bivalved variety. It is valuable to encourage use of every part of the body not incorporated in the cast. When the shell is removed we come to the consideration of convalescence.

**CONVALESCENCE OF SPRAINS:** is speedy after the removal of the immobilization dressings. From this time the treatment of sprain simulates that of strain. Gradual functioning of part to full efficiency is, however, more guarded and slow. Frequently there is more confidence in the use of the part involved with the wearing of an elastic stocking or light leather cover over the area for a short time. This snug fitting support affords a feeling of security, but it must be worn only during the times for functioning and not for any indefinite or long period.

## POSTOPERATIVE MANAGEMENT OF APPENDICEAL PERITONITIS\*

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THE treatment of appendiceal peritonitis may be divided into 3 stages, namely, before, during and after operation. The period before operation is important, not so much from the standpoint of what is done as of what is not done. It is in this period that the decision when not to operate depends upon mature judgment and the courage born of long experience. It would be impossible to set down guiding principles to apply in every case of peritonitis. The course of action must be determined in the mind of the surgeon who sees the patient and it will be determined by his interpretation of the patient's symptoms, the evaluation of physical findings and particularly upon whether the peritoneal infection is diffused or localized. Briefly, the types of peritonitis are the localized, spreading, and the diffused. It is important to bear in mind that this classification does not depend upon the size of the area of peritoneum involved but on the nature and activity of the process which is going on within the peritoneal cavity. The term "general peritonitis," usually is used incorrectly. It is very uncommon to find the entire peritoneal cavity infected since the patient usually succumbs before this condition is reached. Localized peritonitis may occur early in appendicitis when the infectious process has been isolated and confined by a protective barrier made up of neighboring coils of bowel, omentum and peritoneum. It may occur in the subsiding stage of diffused peritonitis when the resisting and protective forces of the peritoneum have stayed the progress of the spread of the infection and caused it to remain confined to a limited area. In spreading peritonitis there are no protective barriers and the infectious

process is being actively disseminated without apparent resistance on the part of the peritoneum. This condition if unchecked becomes diffused peritonitis. Peristaltic activity becomes quiescent, distention appears and the condition of the patient is that of severe toxemia. There is abundant absorption of toxins by the peritoneum and the final issue waits as the balance between the forces of infection and the protective properties of the peritoneum and the general resistance of the patient decide the victory for good or evil. To open the peritoneum during this stage or to disturb in any way the patient's battling forces of resistance is to tip the balance in favor of infection and death. General supportive measures, abundance of fluid and anatomical rest best serve the patient. In a few hours it will be decided whether the patient can weather the storm. If successful, the invading forces will be checked then pushed back and confined to a large or small area on the right side of the abdomen. Peritoneal activity will be resumed. Tenderness and rigidity will be localized. The pulse will become less rapid but the temperature will remain high. This is the opportune time for surgical intervention. The surgical condition is essentially that of a large suppurative collection. The indicated procedure is removal of the source of infection, namely, the appendix, and thorough drainage of the abscess cavity. Spinal anesthesia is of distinct advantage because it permits a deliberate attack without undue haste. During the operation two factors make for success, namely, protection of the uninvolved peritoneum by the proper disposition of gauze, and thorough drainage provided by gauze and rubber tubes and a wide open wound. Following a properly

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conducted operation the subsequent treatment must be conducted along lines which recognize that peritonitis is still present and that the activity of the infection has been exaggerated to some degree by the mechanical intervention.

The sound principles of the Fowler position are very often defeated by careless practice. The proper maintenance of this position requires almost constant attention on the part of the nursing staff, otherwise, the patient slips into the hollow of the bed and assumes a drooping and cramped attitude. Under these circumstances there is, not only failure to maintain dependent drainage of the peritoneum but the structural deformity seems to favor abdominal distention, vomiting and dilatation of the stomach. We have secured more satisfactory results by elevating the head of the bed to an angle of about  $20^{\circ}$  by placing blocks under the bed posts. In this position the patient does not slide down in bed, the spine is not flexed and he is more comfortable.

The use of morphine is confined entirely to the control of pain and restlessness. Usually one or two doses are sufficient. Atropine is not used because we believe that it favors distention by its paralytic action on the intestinal musculature. It also contributes to excessive thirst.

The administration of an abundance of fluid is the most important single therapeutic item. Fluid is not given by mouth because it is usually retained in the stomach until vomiting occurs. Large quantities may be given by proctoclysis but this method has the disadvantage of causing distention of the bowel particularly of the proximal portion of the colon, a region which should not be disturbed. For the administration of fluid we have come to rely principally on hypodermoclysis and intravenous infusion. Two thousand cubic centimeters of fluid can be given under the skin during twenty-four hours and with proper technique and management the dosage is not disturbing to the patient. When so given it is sure to

reach the circulation and it maintains a reservoir of supply for constant use. Intravenous infusion is used when other avenues are insufficient or when the acute crisis of toxemia demands an immediate supply of fluid to the circulation. Glucose in 50 per cent solution is given intravenously as a supportive measure.

Abdominal distention is usually caused by accumulation of gas in the stomach and in the large bowel. The latter condition at times may be relieved by insertion of a rectal tube. The passage of the stomach tube is disturbing to the patient and to the quiet of his abdomen. A Jutte tube introduced through the nose may be readily passed into the stomach without disturbing the patient. It serves to empty the stomach of fluid and gas. While it is in position the patient may be given water by mouth to satisfy his thirst and there will be no danger of accumulation in the stomach. It is not uncommon to have the patient become quiet, comfortable and even to fall asleep after the introduction of the Jutte tube. Vomiting is promptly relieved.

Happily the days are gone when brisk purging was prescribed during the first two or three days after operation for the purpose of reducing abdominal distension. The principles of physiology are ignored by the old textbook term, paralytic ileus. Only a dead gut can be spoken of as paralyzed. The general musculature of the entire alimentary tract is under the control of the parasympathetic nervous system. It will be recalled that in this scheme of innervation there are terminal ganglia in the walls of the gut which are capable of independent action when the preganglionic fiber has been destroyed. In general it may be stated that the parasympathetic nerves of the alimentary tract are essentially motor and that they react to stimulation by causing muscular contractions. There is also an important innervation by sympathetic fibers. These come from the thoracico-lumbar outflow of the spinal cord and terminate in large extrinsic ganglia which are located at a distance

from the structure in which the post-ganglionic fiber finds its agent. The sympathetic has an inhibitory action on the general intestinal musculature, that is, it acts to decrease tonicity. Along the intestinal tract are certain sphincter muscles or sphincteric mechanisms, to wit, the pyloric sphincter, the sphincter of Oddi, probably one at the duodenojejunal juncture, the ileocecal sphincter, probably one at the cecocolic juncture, and the rectosigmoidal sphincter.

There is evidence to indicate that the sympathetic supplies the motor fibers to these sphincters (Gaskel). Under normal conditions there is harmonious coordination between parasympathetic and sympathetic influence which makes possible peristaltic activity and the onward progress of intestinal contents. It appears that the toxemia of peritonitis gives rise to an overactivity of the sympathetic nervous system as evidenced by the blanched, cold and leaky skin and by a general bodily behavior which for want of a better term has been called surgical shock. Within the abdomen, the evidence of hyperactivity of the sympathetic system is intestinal distension. If the assumption is correct that stimulation of the sympathetic fibers causes relaxation of the gut and contraction of the sphincters then distension is explained. Further proof that distension is not a state of paralysis is the fact that following the administration of a spinal anesthetic it promptly disappears. In an extended use of spinal anesthesia I have noted frequently that when the abdomen is opened there is exaggerated peristaltic activity and irritability. Spinal anesthesia truly paralyzes the sympathetic fibers which have their origin in that part of the spinal cord reached by the anesthetic agent. The nerves of the general musculature of the gut are not paralyzed because their origin is high in the cord (vagus) and out of reach of the anesthetic. From the standpoint of pathologic physiology, what is to be done for the relief of abdominal distension? Inquiry has revealed

that it affects principally the stomach and colon probably by reason of incoordination or spasm of the pyloric and rectosigmoidal sphincters. (More pronounced manifestations of the incoordination of these sphincters are infantile pyloric stenosis and Hirschsprung's disease.) The stomach can be emptied and kept so by the use of the Jutte tube. Colonic distension is more difficult to relieve. If extreme, a spinal anesthetic will give prompt results and thus obviate the necessity of making a cecostomy. In milder cases, the use of proctoclysis probably aggravates the condition. It is better to give fluid by hypodermoclysis. A rectal tube passed beyond the rectosigmoidal sphincter with the aid of a proctoscope should relieve the gas distended colon, but this method under the trying conditions presented by a very ill patient is not practicable. Magnesium sulphate has a local sedative action on spastic smooth muscle. It has been successfully used as a local application to the region of the rectosigmoidal sphincter in the treatment of chronic constipation. For several years I have discarded the use of the routine enemas after operation because they are too voluminous, too fatiguing to an ill patient (pulmonary embolism has been reported in causal relationship), and because they are usually ineffectual when most urgently required. Experience has demonstrated that colonic distension is usually overcome by the rectal administration of a small quantity of magnesium sulphate solution. Six ounces of a saturated solution are injected into the rectum with a catheter or syringe and permitted to remain. In half an hour, sometimes longer, the patient has a desire to defecate and will pass quantities of flatus and fecal matter. And there will not be the feeling of depression and weakness which so frequently follow the ordeal of the usual enema. This enema may be given on successive days until distension is permanently relieved. Theoretically, the magnesium sulphate by direct contact relaxes the spastic sphincteric mechanism

of the rectosigmoid. In practice too it works. The fatal agent of peritonitis is overwhelming toxemia made possible by the extensive absorptive area of the peritoneum which exceeds the skin surface of the body. The speed of absorption, other things being equal, is the determining factor in recovery or death. Certain bacteria as the colon bacillus cause an inflammatory reaction in the peritoneum giving rise to an outpouring of lymph and plastic exudate. These are protective forces and delay absorption. Antecedent peritoneal trauma as from operation, in clinical experience, seems to increase peritoneal resistance. Other bacteria, as the streptococci, encounter little resistance from the peritoneum or speedily overcome it, disseminate rapidly, have their toxins freely absorbed into the circulation with the usually fatal issue. Handley holds that intestinal obstruction (ileus duplex) is the cause of death in practically every case of fatal peritonitis. With this, surgical opinion is not in accord. There is no doubt that at times intestinal obstruction supervenes after operation for appendiceal peritonitis. Its most frequent site is the terminal ileum which may be thickened almost to occlusion by extension of inflammation from the abscess cavity of which it partly forms the wall. It is the admonition of Deaver that this potential danger should be recognized at the time of operation and, when present, an ileocolostomy should be done as part of the primary operation.

The general appearance and behavior of the patient suffering from the toxemia of peritonitis suggest a condition of intense stimulation. Cerebration is acute, the pulse is rapid and of small volume and the temperature is high prior to the terminal stage. In a clinical sense the condition is not much unlike a hyperthyroid crisis. Others have noted a suggestive thyroid overactivity in acute infections. Iodine has a specific influence in controlling hyperthyroidism. With this thought in mind, during the past year I have given

Lugol's solution, 1 dr. to the pint of water by protoclysis, to patients having peritonitis. To date my experience has been too limited to warrant conclusive statements. Decidedly beneficial results have been noted, but other factors must be considered which make any inference regarding the effect of iodine a hasty deduction.

The prime reason for use of drainage is maintenance of free communication between abscess cavity and the exterior. A large area of the peritoneal cavity like that in diffuse peritonitis obviously would be impossible to drain. The operative essentials of management of localized peritonitis are adequate incision without thought of incisional hernia, wide open drainage to the utmost limits of the infected area and meticulous care to avoid breaking protective barriers into uncontaminated regions. The use of certain drains is a matter of personal choice. The main objective is an open wound whose free exit from the abscess cavity must not be obstructed by sutures or partially obliterated by the efforts of intra-abdominal pressure. When should the drainage material be removed? Often too early; never too late. It is usually wise to let it come out of its own accord. The exit of pus may be obstructed by improperly placed drains but not by a drain which goes to the bottom of the infected cavity. When the drain is out, the wound should be kept open to its depths and permitted to heal by a gradual filling-in process. Irrigation of the wound is a questionable practice. It may be harmful. No evil can come from pus which is not under tension. Efforts to sterilize the wound, to be followed by secondary closure, are attended by many failures and doubtful advantage when successful. Postoperative intestinal obstruction during convalescence is a difficult diagnostic problem. The symptoms which persist for a few days after operation for appendiceal peritonitis, the postoperative ileus and distention and vomiting so closely simulate obstruction as to make differentiation uncertain. Yet the diagnostic urgency makes delay seem

extremely hazardous. However, when this question arises during the first four or five days after operation a waiting policy is safer. Many of these cases in which obstruction seems to be present will subside spontaneously. To reopen the abdomen in the presence of peritonitis is attended by great risk. It becomes a matter of choosing the lesser of two evils: that is, masterful inactivity. It is the practice of some surgeons to make an enterostomy in these cases of questionable obstruction hoping thereby to err on the side of safety. Adequate statistics on this procedure are not available. It is difficult to conceive how a jejunostomy, draining only a short segment of bowel, could be beneficial in the type of intestinal obstruction here considered. There is much to indicate that

it is often actually harmful. It does not release the obstruction. It forms a jejunal fistula which in experimental work has proved to be more rapidly fatal than high intestinal obstruction. The solution of the problem seems to be first, recognition of potential obstruction at the primary operation and prevention by a short circuit anastomosis (ileocolostomy) as advocated by Deaver, and second, if this has not been done and symptoms of obstruction arise which cannot be differentiated from peritonitis, follow a policy of watchful waiting. Murphy said, "There is no more perplexing problem in all surgery than to decide when to reopen the abdomen with symptoms of postoperative ileus; the more experience one has the more one appreciates the inadequacy of diagnostic guides."



# SPINAL ANESTHESIA USED AS A PREOPERATIVE INDEX TO GANGLIONECTOMY IN MEGACOLON\*:

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IN 1927, Wade and Royle reported: In a series of 25 cases of congenital spastic paraplegia in which bilateral lumbar sympathetic ramisection was performed, 13 patients suffered from chronic constipation, and 11 were relieved. In a number of these cases a dilated colon was found at operation.

Wade later reported 4 more cases in which ganglionectomy was done with unsatisfactory results in two. Ganglionectomy for megacolon is now being used with increasing frequency and a proper index for the selection of such cases for this operation is highly desirable.

In brief, our method has been to give a patient what may be called a spinal anesthesia test. The patient is given a barium enema and an x-ray taken of the entire colon. This is the control picture. Then a high spinal anesthesia is performed and a series of radiographs taken. If the colon becomes active and shows peristalsis and a decrease in size, the case is considered as a satisfactory one for ganglionectomy.

## RATIONALE

The interpretation of this test deals entirely with the nerve supply of the large gut. The myenteric plexuses of Auerbach and Meissner have the sole action of producing contraction above and relaxation below the point stimulated. The sympathetic nerves arise from the fifth dorsal to the sacral segments of the cord, are distributed mainly through the four lumbar ganglia, and when stimulated produce dilatation of the colon. The parasympathetic system consists of the cranial branches through the vagus controlling the ascending and proximal half of the colon, and the sacral branches supplying the remainder of the large gut.

The object of the test is to produce a

blocking of the thoracolumbar outflow of the autonomic nervous system by spinal anesthesia. This also blocks the sacral parasympathetics as well as the entire cord as high as the level of analgesia leaving only the cranial parasympathetics to exert their full influence. The portion of the gut to be observed then, is the ascending and transverse colons.

The test then is, in part, a temporary ganglionectomy. What remains to be studied is whether this test conforms with postoperative findings, and if so, to what extent. The test has been used by us on 1 case with completely successful results. It also answers the unsuccessful results of operation in certain cases in that they were not due to a hyperactivity of the sympathetic system.

## CASE REPORT

The patient, admitted July 8, 1930, to St. Mary's Hospital, is a young woman of twenty-three years of age, who ever since she could remember had marked constipation and irregular periods of distension particularly after carbohydrate ingestion and headaches for which she used many aspirin tablets. The most distressing symptom, however, was the presence of severe crampy epigastric pains radiating to the left and to the back. Elsewhere an appendectomy was performed on her two years ago, and following this all her symptoms became aggravated. The constipation became absolute; laxatives and purgatives produced no effect; she actually bought gallons of mineral oil but only an enema gave some relief. The attacks of pain increased in frequency and severity. The headaches became worse; periods of distension still recurred though she remained on a carbohydrate-low diet for months.

Physical examination revealed a fairly well developed young woman with all systems negative for abnormalities except for tenderness

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under the left costal border and costovertebral angle. Examination of the urine showed it to be alkaline of specific gravity 1019, and negative for albumin and sugar. The blood showed 80 per cent hemoglobin; 4,600,000 erythrocytes; color index of 0.8. The white cells numbered 8100 with 62 per cent neutrophils, 32 per cent small lymphocytes, and 6 per cent endothelial leucocytes. Kahn test was negative. Temperature ranged from 97 to 99°F.; pulse from 60 to 80.

She was first referred to the Medical Service where a cystoscopy and pyelogram were done with negative findings. Rectal examination revealed a posterior fissure and sentinel pile, and a hemorrhoidectomy was performed. Since there was no amelioration of the symptoms she was considered a neurotic. A barium enema was given and she was found to have a massive dilatation of the entire colon, especially the proximal half with a low-hanging transverse colon. She was then referred to the Surgical Division and the test was first tried on her as follows:

1.00 P.M. Barium enema and x-ray. Control (Fig. 1).

1.10 P.M. Spinal anesthesia with 200 mg. novocaine crystals.

1.20 P.M. First test ray. Anesthesia at level of epigastrium.

1.40 P.M. Second test ray. Anesthesia at level of clavicle, i.e., fourth cervical (Fig. 2).

2.15 P.M. Third test ray. Same height of anesthesia.

3.15 P.M. All anesthesia gone.

Next day at 10.00 A.M. Fourth test ray.

Preoperative preparation included a low carbohydrate diet; daily soapsuds enema; ½ oz. mineral oil three times daily after meals; and ⅛ grain strychnine sulphate by mouth twice daily.

Operation was done on August 22, 1930, under ether anesthesia and lasted one and one-half hours. Adson's intraperitoneal approach was used; on the right side four lumbar ganglia were removed and on the left only three for the first ganglion was abnormally high. The colon was found markedly distended; no adhesions at all were present as a result of the previous appendectomy.

The postoperative course was not uneventful in the first week. The patient had two sudden attacks of dyspnea, palpitation and numbness followed by anesthesia over the right half

of the body; both attacks lasted one hour and were entirely relieved by morphia.

This was followed for several days by sharp shooting pains in her legs. After three weeks the patient was allowed to get up. It is now eight months after the operation and the results are as follows:

a. Gain of 20 lb. in weight.

b. General feeling of well-being.

c. *Regular* daily bowel movement since operation (sometimes two in one day) *without* the use of laxatives.

d. Fluoroscope shows twenty hour elimination (Fig. 3).

e. Barium enema and x-ray of colon show result to be even better than that shown by test. Fluoroscopy shows a live active colon.

f. Entire cessation of headaches.

g. No attacks of abdominal pain.

#### COMPARISON OF TEST WITH RESULTS OF OPERATION

Even in the large dilated colon, under fluoroscope, there were varying periods of inactivity and slight activity. This activity became much greater during the test and following operation. To accurately compare results on several fixed films is a very difficult matter for it does not denote the constant change of size, shape and amount of peristalsis. Even with this in mind, a comparison of the films in this case is justifiable and represents the actual state.

The following are the widths of the colon during the test and after operation:

	Control	1st ray	2nd ray	3rd ray	Post-operative
Ascending.....	4	3	3	3	2
Proximal ½.....	4	3	3	2	2½
Distal ½.....	3	2½	2½	2	2½
Descending.....	2½	2	2	2	2

During the test peristalsis increased in depth and frequency and the transverse colon became elevated. The findings of this test conform well with the parasympathetic innervation of the large gut; the cranial portion supplying ascending and proximal two-thirds of the transverse colons, and the sacral portion the remainder. And it is over the area supplied by the vagus that shows the greatest changes.



FIG. 1. Control ray just prior to test.



FIG. 2. Colon at height of test one hour after performance of test.

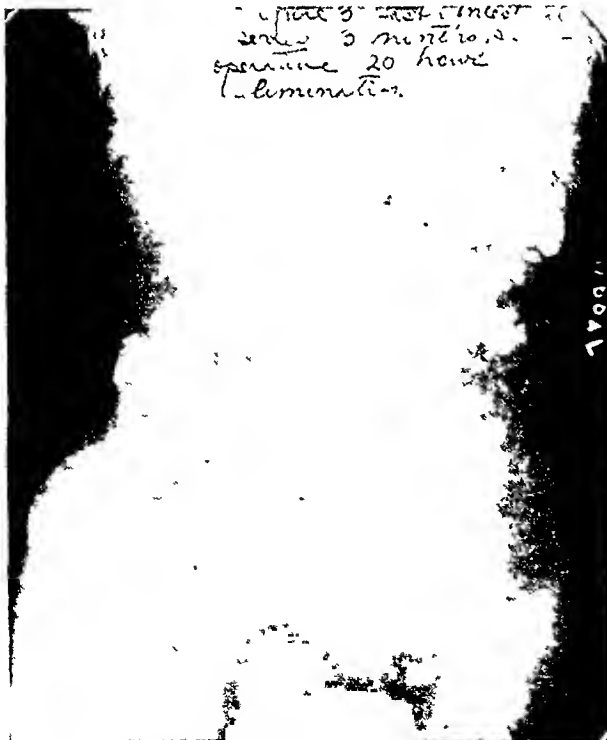


FIG. 3. Gastrointestinal series three months postoperative. Twenty-hour elimination.



FIG. 4. Barium enema three months postoperative.



One may conclude then, an existing hyperactivity of the sympathetics. In the distal half of the gut where both sympathetics and



FIG. 5. Note wavy fibrils irregular sized nuclei and diminished size of stromal nuclei.

parasympathetics are blocked one would expect to get no changes, but there is increase peristalsis with practically no change in the width of the gut. Postoperative results are even better than those found during the height of the test, due probably to the greater time given for readjustment of the parasympathetics. Thus, postoperative results compare favorably and are even slightly better than those during the test. The test, then, is not only an index to operability but also gauges roughly the amount of benefit to be expected.

#### PATHOLOGY

The pathological report was prepared by Dr. James E. Davis and is as follows:

*Microscopic Examination:* Section is a sympathetic ganglion exhibiting some irregular thickening and irregular hyalinization of the blood vessel walls and narrowing of the lumina. There is slight hyalinization of the stroma and some contraction of the entire tissue with

slight atrophy of some of the nerve cells. There is some increase in cellularity, doubtless due to contraction.

Section is of lymph node tissue and fatty structures and shows Grade 2 of vascular sclerosis and hyperplasia.

*Diagnosis:* Mildly sclerotic ganglionic tissue.

The pathological inference is that of a toxic factor being the cause for the clinically hyperactive ganglia and the degenerative changes shown in them.

#### DISCUSSION

The advantages of the test are threefold: it offers a method of selection of cases for ganglionectomy; it eliminates needless operations; and it gives a rough measure of the benefit to be desired.

From the etiological point of view, it divides megacolon into two large types, those due to a sympathetic hyperactivity and those due to other causes.

It is the former type of case which is benefited by ganglionectomy; and this test selects that case. The same test may be used in the atonic types of severe constipation which may be considered for this surgical procedure. A further use of this test lies in cases of Raynaud's, Buerger's and other vaso-obstructive conditions where calorimetric measure of the blood flow of the limb both before and during the spinal anesthesia may be determined and the increase in blood flow determined. If there is a great increase in blood flow, the case then is suitable for ganglionectomy.

#### CONCLUSIONS

1. The spinal anesthesia test may be used as an index to ganglionectomy for megacolon.

2. A case of megacolon is described on which both test and operation were done with complete confirmation of results.

3. Etiologically, megacolon may be divided into those cases due to sympathetic hyperactivity and those due to other causes.

4. The test may be further used in the vaso-obstructive conditions considered for ganglionectomy.

5. Pathological lumbar ganglia are reported.



# SPINAL CORD COMPRESSION:

## TUMORS AND ALLIED NON-TRAUMATIC CONDITIONS\*

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**T**UMORS of the spinal cord rank first among those neoplasms, which if diagnosed and removed early in their development, can be permanently cured. The symptoms produced by these lesions result from compression of the spinal cord within its bony compartment. Consequently, any condition producing compression of the spinal cord may simulate tumor so closely that a differential diagnosis is very difficult.

Trauma, infection and neoplasia, associated with compression, usually can be accredited with derangement of function of the spinal cord. A history of injury, together with roentgenologic evidence, is generally sufficient for a diagnosis of traumatic myelitis; furthermore, the history and cytologic examination of cerebrospinal fluid commonly give sufficient evidence for a diagnosis of acute infectious myelitis. But slowly increasing pressure on the spinal nerve roots, and on the cord itself, by chronic infective and neoplastic processes, including tumors, creates such a multiplicity of symptoms that in some cases a differential diagnosis is impossible until laminectomy is performed.

However, a differential diagnosis between compression of the spinal cord and degenerative lesions of the spinal cord should be made by means of a complete neurologic examination, including tests which will elicit any changes in the motor or sensory functions of the cord. The physician should carefully examine the change in reflexes and vibratory responses, as well as in the spinal fluid, with particular attention to change in pressure, color and cytology. Lipiodol should be used in conjunction with a complete neurologic examination in order further to establish diagnosis. A roentgenogram of the vertebral

column, as well as examination for primary malignant disease, is also significant.

*Surgical Intervention:* Exploration of the spinal cord and its membranes carries with it little risk and can be done with minimal loss of function. In many borderline cases, preoperative pathologic diagnosis is almost impossible, and in spite of clinical syndromes and neurologic observations, the diagnosis is made at operation.

The consensus of opinion among neurosurgeons seems to be that in any case of dysfunction of the spinal cord, due to slowly developing compression, exploration should be carried out, provided that a distinct level of sensory disturbance is present and definite subarachnoid block can be demonstrated. No two patients give the same history or present the same evidence on neurologic examination. Certain clinical developments, such as the cycle described by Frazier; namely, root pain, Brown-Séquard syndrome, and paralysis, may be evident but this classical progression of symptoms is seldom seen. Loss of sphincteric control due to compression of the spinal cord usually comes late in extramedullary tumors and early in intramedullary involvement; frequently, however, sphincteric function is lost early in an extramedullary lesion.

Cases also are observed in which the history is classical for tumor, but when exploration is made, the pathologic changes of the spinal cord prove to be inflammatory rather than neoplastic. Again, the most bizarre of histories and signs may be produced by a simple neurofibroma or endothelioma. Consequently, the pathologic changes in compression of the spinal cord should be of primary consideration in any surgical discussion.

Laminectomy can be performed by

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several different methods. Mechanical removal of the spine and laminae is not so important as close observation of the tissue removed. The texture of the removed bone should be carefully scrutinized for evidence of any changes, either of absorption or of overgrowth. Then the epidural space requires a critical survey for signs of neoplastic or inflammatory changes. If the exploration has been negative up to this point, then the dura should be carefully examined for any abnormalities of pulsation. Absence of pulsation means one of two conditions: either the compression is above the laminectomy opening or the exposed dura lies just over it. Gentle palpation of the dura rules out the latter condition, and if there are no signs of compression, the laminectomy must be carried cephalad until there is definite pulsation of the dura. During the operation, it must be kept in mind that accurate as the localization has been, there is always danger that the level of the abnormality, as determined before operation, may be one segment lower than the actual compression of the cord.

After it has been demonstrated that the cause of compression is not extradural, and the pulsating dura has been exposed, operation should proceed by incising the dura longitudinally. Should no cause of compression be evident, and the operator be at a loss to explain the absence of pathologic change, then a silver probe or soft rubber catheter should be gently inserted intradurally to eliminate the possibility of an obstruction either above or below. The cause of the compression may lie anteriorly to the spinal cord and perhaps can be exposed only after the cord has been rotated by means of the dentate ligament.

Lesions within the spinal cord may cause compression. The majority of these lesions involves a discouraging prognosis; yet cysts have been evacuated, benign tumors have been completely removed, and recovery has resulted from the decompression incidental to the laminectomy.

Complicating the preoperative patho-

logic diagnosis of tumors of the spinal cord are inflammatory lesions which develop insidiously, and which simulate such tumors so definitely that a differential diagnosis can be made only at operation. Pachymeningitis due to tuberculosis, syphilis, or other chronic inflammatory lesions may prove to be the cause of compression. Chronic cystic arachnoiditis may be encountered when the dura is opened. Varicosities of the meningeal vessels may simulate tumors, although such a condition may be found adjacent to tumors, making the diagnosis of varicosity possible only after the presence of a tumor has definitely been excluded. The surgical and pathologic aspects of compression of the spinal cord are so closely interwoven that until a complete examination of the vertebrae, meninges and cord has been carried out, the operation should not be terminated nor the diagnosis completed.

*Pathologic Changes:* A review of the literature of the tumors of the spinal cord reveals that the pathologic classification is more or less in a state of chaos. This may be explained by the great diversity of opinion between pathologists, and is readily understood when the different fundamental principles are considered. The three primitive germ layers, namely, endoderm, mesoderm and ectoderm, were selected as the progenitors of all tissue structure, and it was believed that any tumor must develop from one of these layers. Following closely on this came the "cell rest theory," which assumed that inclusion of embryonic tissue took place during development, and that the included tissue lay dormant for an indefinite period, and then suddenly became active. Proliferation of these cells resulted in tumors and rapidity of growth, and the presence of a restraining capsule determined whether they were benign or malignant.

As time advanced, the search for the causative factor of tumors was directed to the predominating cell. Taking into consideration the different stages of the development of the individual cell, it was

discovered that there were reserve cells for every type of cellular structure. These embryonic cells had the potentialities for developing into certain specialized adult cells, but under the influence of an environmental change, they might alter their function. It was also discovered that these embryonic reserve cells, regardless of their supposed parentage, closely resembled one another. Then a cytologic resemblance between malignant tumor cells and embryonic tissue cells was emphasized. From this developed a biologic conception of neoplasia, which placed a pathologic classification on a logical basis. According to this conception, metaplasia, when reviewed from a cytologic standpoint, offers an explanation for extraordinary and unusual cellular structure. Likewise, malignant tumors are comprehended with greater facility because they appear to be due to hyperplasia or to multiplication of reserve or embryonic cells. Finally, the grading of malignant tumors was made possible by the evaluation of the amount of cellular differentiation found on microscopic examination.

From the brief outline of the different premises on which pathologic analysis has been based, one can readily understand the difference of opinion, even among leading authorities. To complicate further the nomenclature, as applied to neoplasms, the surgical pathologists who deal with fresh tissue, and the surgeons who base their conclusions on clinical, surgical and pathologic evidence, have added observations to the literature.

For this reason, an attempt has been made, by means of an orderly, systematic analysis of tumors of the spinal cord encountered at the operating table, to develop a more intimate interrelationship between the diagnostic, surgical and pathologic aspects of such tumors. The following pathologic analysis is based on accepted and authenticated terminology, and microscopic studies have been carried out by means of fixed frozen sections stained with hematoxylin and counterstained with cosin.

These observations are to be used as a basis for further study with various special stains which probably will eliminate many points about which there now seems to be a diversity of opinion.

The following tabulation, based on a series of 312 cases, illustrates the multiplicity of tissue changes which can cause compression of the spinal cord.

The tabulation, although useful as a comprehensive summary of pathologic observations, might prove confusing; so, for the sake of convenience, a simpler grouping, intradural, extradural and intramedullary, has been used. The relative frequency and the anatomic distribution of the lesions in 312 cases were as follows: extradural, 67 cases; intradural, 156 cases, and intramedullary, 89 cases. What is to follow is based largely on a consideration of these 312 cases.

#### EXTRADURAL TUMORS

Any condition of compression of the spinal cord which clinically could not be distinguished from actual neoplasm has been included in this series. Metastatic lesions, tumors of the bone and intervertebral disks, as well as inflammatory lesions, may be found at operation and may or may not have been diagnosed before operation.

Knowledge of the tumors which the surgeon may encounter is always to be desired. Meyerding has classified tumors of the bone, using the bones of the extremities as a basis. But the same tumors may occur in the vertebrae and cause compression of the spinal cord. Rand recently reported cases of extradural coecidioid granuloma which seem to occur only in the southwestern part of the United States or Mexico. Echinococcus or hydatid cysts have been reported as causing compression of the spinal cord; they also are thought to be confined to certain regions of the body but they may be encountered when least expected. The extradural lesions have been grouped and listed according to their pathologic diagnosis and frequency of occurrence as found at operation.

*Fibroma (3 Cases):* The first tumor of the spinal cord removed by Horsley was an extradural fibroma. These fibroblastic tumors are not common, and yet they are sufficiently common to be significant because of their benign character. Fibromas may arise from any fibroblastic structures of the spinal cord and may be intramedullary, intradural or extradural. The tumors referred to in this paragraph were simple fibromas; the neurofibromas and the fibrosarcomas were not included.

*Lipoma (1 Case):* According to Frazier, lipomas are rare except when associated with spina bifida and they usually are found in the lumbar region. The one extradural lipoma was removed from the cervicodorsal region. These fatty tumors develop slowly, on gross examination somewhat resemble fibromas, and in spite of their softness may inflict serious pressure on the cord.

*Glioma (2 Cases):* Extradural gliomas are probably extensions into the epidural space of tumors of the spinal cord, or according to Kernohan, they may be heterotopic masses of glial cells growing in the meshes of the pia arachnoid. Diagnosis was made from tissue removed during laminectomy for an extradural tumor. An apparently malignant tumor was encountered following removal of the spines and lamina. It was so extensive that further operation was contraindicated.

*Osteoma (3 Cases), Osteosarcoma (2 Cases), and Hypertrophic Osteitis (7 Cases):* Boyd, in a consideration of the osteogenic group of neoplasms, pointed out the difficulty in determining whether any new formation of bone should or should not be regarded as a true neoplasm. There are many inflammatory and traumatic conditions associated with formation of bone, such as the callus of fracture, the ossification of inflammatory exudates in various parts of the body, and the bony outgrowth around joints, which are the seat of chronic arthritis. These do not present any essential differences from the masses of bone which are recognized as true osteomas. The microscopic picture is of little value as

a means of differentiation except in the case of malignant change. The condition described as hypertrophic osteitis, or hypertrophic osteoarthritis by Parker and Adson, is really an overgrowth of soft, spongy, vascular bone, inflammatory in character, which constricts the vertebral canal and may be associated with an overgrowth of bone around the vertebral foramina. A preoperative diagnosis of this condition is rather difficult, due to the fact that roentgenologic examination is not of marked value.

*Metastatic Tumors: Carcinoma (1 Case), Fibromyxosarcoma (2 Cases), Fibrosarcoma (1 Case) and Hypernephroma (1 Case):* Woltman had aptly stated that metastasis of malignant tumors to the central nervous system is a derelict encountered in our diagnostic lanes. Unsuspected primary lesions may be responsible, and therefore metastatic lesions must be eliminated from consideration by careful general and neurologic examinations. Fortunately, the nature of the lesion generally can be detected by roentgenograms, and Woltman has studied 136 cases in which the condition was diagnosed by roentgenologic methods in 98. The symptoms may be the same as those of any benign tumor of the cord except that the progress of malignant growth is usually more rapid. Often when no primary growth can be found and sometimes when primary malignancy is evident, as in the 2 cases of fibromyxosarcoma of the uterus and in the case of fibrosarcoma of the popliteal space, exploration should be done, not only to establish a diagnosis but also as a palliative measure.

Whenever a patient presents the picture of rapidly developing compression of the spinal cord, with all of the clinical manifestations of a tumor of the spinal cord, and without evidence of primary malignancy, exploratory laminectomy should be done as a diagnostic as well as a palliative measure. Such was the situation found in 1 case of metastatic hypernephroma. At operation, a malignant tumor was found compressing the cord in the epidural space. On gross

examination the tumor presented the characteristic yellowish-red, granular, friable appearance, and on microscopic examination, the usual malignant cells, distended with gelatinous material, the so-called foamy cells of hypernephroma, were found. The etiology of hypernephroma has long been a subject of dispute. Ewing expressed the belief that this type of tumor is a papillary carcinoma primarily of nephritic origin, whereas Grawitz formulated the conception that certain tumors of the kidney were derived from suprarenal rests. Malignant tumors of the type of hypernephroma are always prone to metastasize to bone. Sometimes the most exhaustive search for a primary focus may prove unsuccessful, and only during exploratory laminectomy is metastasis to the spine encountered.

*Sarcoma (2 Cases) and Lymphosarcoma (2 Cases):* Clinically the diagnosis was extradural tumors of the spinal cord, and at operation a cellular tumor was encountered which filled the epidural space. As much of these tumors as possible was removed, and on microscopic examination 2 of them were found to be sarcoma and 2, lymphosarcoma.

*Neurofibroma (13 Cases):* This tumor, designated by Penfield as perineural fibroblastoma to distinguish it from peripheral neurofibroma, comprises the second largest number of tumors of the spinal cord in the series of 312 cases. Although this section is devoted to extradural tumor, it may be well, in taking up the neurofibromas, to take a broader view. In the entire series of 312 cases there were 68 cases of perineural fibroblastoma in which the growth originated from the spinal nerves and was found to be growing extradurally, intradurally and intramedullary. Fifty-two of the 68 tumors were found to be attached to the nerve roots within the dura, and did not involve the spinal cord except by compression. In 3 cases the tumor was shaped like a dumb bell; one part was attached to the nerve roots outside the dura, and extended through the interver-

tebral foramen to the other portion of the tumor, that lay outside the vertebral canal. In 2 cases the neurofibroma had developed within the spinal cord. The origin of these intramedullary tumors is rather difficult to understand, but recently I reported a case of neurofibroma of the spinal cord in which the tumor was buried in the cord but was easily enucleated. These perineural fibroblastomas arise from the perineural or endoneural connective tissue which invests the fasciculi and fibers, and some authorities, such as Roussy, Lhermitte, and Cornil have classified them with the gliomas. Penfield has proved conclusively by differential stains that they are fibroblastic in structure. Microscopically, the structure is characteristic. There is palisading and parallelism of nuclei, and a tendency to form nuclear eddies and streams. These tumors are benign and encapsulated, and may be completely removed. The prognosis following complete removal of such benign tumors depends on the amount and duration of compression of the spinal cord.

*Fibrochondroma (6 Cases) and Chondroma (3 Cases):* According to Boyd, cartilaginous tumors of bone occur in the course of the period of growth of bone, and tend to cease developing when that period is over. They may also occur in bone which arises chiefly from portions of cartilage which probably have become misplaced through some error of development. The extradural chondroma causing compression of the spinal cord usually arises from the intervertebral disks; Dandy has reported 2 cases of detached intervertebral disks protruding into the spinal canal and causing compression. Ewing stated that trauma and inflammation are usually the causes of chondroma, and trauma is not infrequently reported as preceding chondroma and fibrochondroma. These tumors are sometimes diagnosed preoperatively by means of roentgenologic examination, and may be difficult to distinguish from the roentgenologic picture of giant cell tumor of bone because of the tendency to form cyst-like cavities. The

cases of fibrochondroma and chondroma mentioned in this paragraph were distinguished by the predominance of fibroblastic tissue around the chondromatous cells.

*Tuberculoma (4 Cases):* Tuberculomas of the spinal cord and its membranes seldom occur unaccompanied by tuberculous disease of the vertebrae. Tuberculous infection may remain limited to the dura, producing pachymeningitis, or may pass to the pia and arachnoid, producing leptomeningitis. If the pachymeningitis is secondary to vertebral disease, the tubercles at first are external and the inner surface of the dura may suffer secondarily. Tuberculosis of the pia arachnoid may be of hematogenous origin, the disease beginning about the vessels of the pia. Compression of the spinal cord caused by a tuberculoma, unassociated with vertebral involvement, as evidenced by roentgenologic examination, is very difficult to distinguish from other types of compression of the spinal cord. Exploration was performed in these cases under such circumstances of difficulty in diagnosis, and the condition was found to be tuberculosis of the dura, extradural in situation, and taking the form of tuberculous pachymeningitis.

*Hemangioma (3 Cases) and Hemangioendothelioma (5 Cases):* Vascular tumors of the spinal cord which occur extradurally arise from vessels which normally are found lying extradurally. On gross examination it is often difficult to distinguish between hemangioma and hemangioendothelioma, and such distinction can be made only by microscopic examination. Hemangiomas are benign, but hemangioendotheliomas may be either benign or malignant, depending on the type of cell most prevalent. Tumors of this type are usually of slow growth, as evidenced by supporting connective tissue stroma. An extradural hemangioma was removed from the cervicodorsal region, and a hemangioendothelioma found extradurally was removed from the seventh dorsal segment.

*Foreign Body Giant Cell Tumor (4 Cases);*

For many years, this condition was diagnosed as giant cell sarcoma and was treated as a malignant neoplasm. It has also been called myeloid sarcoma. According to Ewing, Nélaton first fully described this tumor as a benign process in bone, emphasized its red, jelly-like appearance, noted its capacity to absorb bone, and established its benign course and the reasonableness of conservative treatment. The reputation of the tumor as a malignant growth probably arises from the fact that repeated local irritation, in the form of curettage, sometimes results in the development of malignant spindle-cell sarcoma. Barrie considered that the process was inflammatory and not neoplastic, and that it was a chronic inflammatory, hemorrhagic osteomyelitis. A distinct relationship seems to exist between giant cell tumor and osteitis fibrosa cystica, although this has never definitely been verified. A giant cell tumor may be periosteal or medullary, and it is the medullary type which is found involving the vertebrae. The gross appearance is characteristic, and must be carefully distinguished from that of malignant hemorrhagic endothelioma. The tumor is very vascular and suggests young granulation tissue. It is dark red, and soft. According to Boyd, microscopically the tumor is made up of spindle-shaped cells without hyperchromatic nuclei, and in addition, the characteristic giant cells which gave the condition its name, are found. These may be very numerous in one part of the mass, and scanty or absent in another. The giant cells are characteristic of foreign body giant cells in that they possess small, oval nuclei which are situated toward the center of the cell and not around the periphery or at one end, as is commonly seen in tuberculosis. The cytoplasm is opaque and stains deeply. These cells, whose function is probably destructive, are regarded by some as osteoclasts, but the appearance is probably more characteristic of endothelial cells.

*Unclassified Tumors:* In 2 cases the tumors were not classified.



## INTRADURAL TUMORS

Intradural extramedullary tumors of the spinal cord (156 cases) comprised approximately 50 per cent of the present series of tumors that compressed the spinal cord. Fortunately they were, for the most part, capable of being removed at operation. Neurofibromas and meningeal fibroblastomas predominated and contributed to the entire series a background of favorable prognosis.

*Fibroma (3 Cases) and Fibrosarcoma (2 Cases):* These fibroblastic tumors which lay within the dura and did not involve the spinal cord, except by compression, were primary tumors and were completely removed at operation. They presented the usual microscopic appearance, and the malignant changes were those which occur in tumors of similar structure elsewhere.

*Endothelioma (75 Cases): Arachnoid Fibroblastoma; Meningeal Fibroblastoma; Leptomeningioma:* The terminology applied to these meningeal neoplasms has resulted in a rather confused nomenclature. Until 1921, they were commonly considered as dural endotheliomas. At that time, Mallory demonstrated that the "type cell" of the dural endothelioma lays down fibroglia, although in the more rapidly-growing regions none of these fibers can be found. Consequently, he proposed the name arachnoid fibroblastoma. Elsberg, in 1925, pointed out that in the spinal cord these tumors are sometimes attached to the dura but have no attachment to the arachnoid, suggesting the possibility that in such cases they arise from the cells on the under surface of the dura which correspond to those opposed to them in the arachnoid. Lecombe, in 1927, in a comprehensive monograph emphasized the outstanding characteristic of these tumors and called them leptomeningiomas. Virchow observed the prevalence of "sand bodies" in these tumors, and designated them as psammomas, due to concretions or psammoma bodies. Later they were called endothelial psammomas because of the microscopic picture, in which neoplastic nuclei were

seen. The nuclei are usually fat and oval, and often arranged in columns, or more typically in whorls, which may have as their center a collagen fiber, a small vessel, or no demonstrable structure. In the whorls or elsewhere in the tumor, small concretions of calcium often appear which are similar to the corpora amylacea found in other parts of the body. Penfield, in a recent study of fibroblastoma and arachnoid fibroblastoma, stated that in view of the fact that there may be no demonstrable attachment of the arachnoid and that the tumor indubitably is of fibroblastic structure, a more satisfactory terminology would be meningeal fibroblastoma. These tumors are found predominately to be intradural but extramedullary, and to form the largest single class of tumors of the spinal cord. The 75 meningeal fibroblastomas were found at operation and were removed. Fortunately, in view of their numerical incidence, they carry an excellent prognosis postoperatively. Although benign and encapsulated, these tumors have a tendency to recur if their dural attachment is not removed at the time of operation.

*Hemangioma (7 Cases) and Varix (4 Cases):* Tumors of vascular origin which arise from the vessels within the dura may be grossly neoplastic in character, or may assume the proportions of varicose veins. The former have been considered with extradural hemangiomas. The latter may occur with or without an associated tumor but a diagnosis of intradural varicose veins can be made only after exhaustive examination at operation because it has been demonstrated that compression of the spinal cord due to tumor causes vascular stasis and enlargement of the vessels. When varicose veins are found causing compression of the spinal cord, the decompression resulting from laminectomy usually relieves the clinical symptoms, but when possible the veins should be ligated and removed. The intradural hemangiomas were removed, and were found to have the characteristic microscopic picture. In the

4 cases of varix, tumor was not associated with the compression of the spinal cord.

*Glioma (5 Cases):* On microscopic examination these tumors proved to be gliomas. These tumors were intradural and did not seem to have any connection with the spinal cord itself, but they probably were extensions from the spinal cord proper, although no evidence of an associated intramedullary tumor could be found. This type of tumor will be considered with the intramedullary group.

*Neurofibroma (52 Cases):* Second only to meningeal fibroblastoma in number, intradural neurofibromas were found to be the cause of compression of the spinal cord and were removed at operation. Fortunately, also, although numerically predominant, they resemble meningeal fibroblastomas in being benign and encapsulated. On gross examination their appearance is characteristic. The microscopic appearance has been considered under neurofibromas occurring extradurally.

*Ependymoma (6 Cases):* Tumors of the spinal cord found attached to the fibers of the cauda equina have proved tremendously difficult to classify pathologically. Elsberg referred to them as giant tumors of the cauda equina, and described them as growing to a large size among the nerves. In this series of cases caudal tumors were found to be either attached to the nerves themselves or to the filum terminale. When, on gross examination, they did not involve the conus medullaris, they were classified as intradural extramedullary tumors and were identified microscopically as hemangioma, ependymoma, or neurofibroma. The hemangiomas and ependymomas are similar in their gross characteristics; both of them are found attached to the filum terminale and both may be completely removed. The 6 tumors found proved on microscopic examination to be similar to the intramedullary ependymomas and evidently had their origin in the filum terminale. On gross examination, they were found to be the type of tumor which could be completely removed by

excising the filum terminale above and below.

*Fibrochondroma (2 Cases):* These tumors were similar in structure, microscopically, to the extradural group of tumors. The explanation of these tumors occurring within the dura is rather difficult, unless the theory is accepted that they were heterotopic or extended through the dura. No evidence of extradural chondroma could be found in either case, however. The tumors were benign and encapsulated, were attached to the dura, and did not involve the spinal cord except by compression.

#### INTRAMEDULLARY TUMORS

The intramedullary group of tumors (89 cases), fortunately is much smaller than the extramedullary group, and although most of them arise within the canal and infiltrate the cord, occasionally a benign encapsulated tumor is encountered which can be removed.

*Glioma (25 Cases):* The predominant neoplasm in the present series of intramedullary tumors was found to be a glioma arising from neural elements of the cord. These gliomas are prone to infiltrate the cord, although they may be separated from the surrounding tissue by a region of softening. Although only 25 tumors were demonstrated microscopically to be gliomas, the majority of those which are listed with the miscellaneous and unclassified growths were undoubtedly gliomatous. In some instances, these tumors were partially extruded from the cord following longitudinal section. One proved to be an intramedullary vascular glioma which had extended outside the cord and which had been partially extruded before operation.

*Ependymoma (19 Cases):* These tumors originate from the ependymal cell of the central canal of the spinal cord, and differ microscopically from gliomas in that the cells are flat and elongated.

*Neurofibroma (3 Cases), Meningeal Fibroblastoma (2 Cases), Fibroma (2 Cases) and Fibrolipoma (1 Case):* Intramedullary



tumors rarely are encapsulated and susceptible of being enucleated, but of all of the tumors mentioned in this paragraph, some of the tissue could be removed, and in a few cases complete extirpation was possible. Therefore they should not be classified as true intramedullary tumors. The microscopic structure has been considered previously.

*Sarcoma (2 Cases) and Carcinoma (2 Cases):* Metastatic tumors of the spinal cord have been considered with the extradural group. Lesions primary to those mentioned in this paragraph were not demonstrable. The tumors were diagnosed microscopically. Prognosis is similar to that in other cases of metastasis of malignant growths.

*Cysts (6 Cases):* Intramedullary cysts of the spinal cord are relatively rare. They may cause changes in the cord similar to those which follow compression by solid neoplasms, and are difficult to distinguish preoperatively. These cystic cavities within the cord, indistinguishable in their clinical characteristics from solid neoplasms, are usually gliomatous although it is sometimes difficult to demonstrate any tumor tissue in the walls of the cysts. In 1 case of this series, on clinical examination there was an indeterminate level of sensory disturbance with a subarachnoid block. Lipiodol was injected intrathecally, and a typical dome-shaped shadow of a tumor of the spinal cord was demonstrated in the roentgenogram. At the level of the shadow, an enlargement of the spinal cord was found at operation. The lesion did not have the gross characteristics of an intramedullary tumor, but seemed to fluctuate; when aspirated, yellow fluid was obtained but tumor tissue could not be found, even after dorsal incision in the spinal cord had been made.

Consideration of cysts of the spinal cord would not be complete without some reference to syringomyelia. This condition can usually be distinguished clinically from tumor of the spinal cord, but symptoms of compression of the spinal

cord associated with subarachnoid block of the cerebrospinal fluid may so mask the differential diagnostic signs that exploration is resorted to in order to determine the underlying pathologic changes. Relief may follow the release of the fluid and the associated compression.

There were 27 miscellaneous and unclassified tumors.

#### SUMMARY

Tumors of the spinal cord, if diagnosed and removed early in their development, can be permanently cured. Any condition which produces compression of the spinal cord may simulate tumors of the spinal cord.

In order to correlate more fully the relation of clinical, surgical, and pathologic aspects of compression of the spinal cord, material gathered from cases reported at The Mayo Clinic from 1912 to 1929 has been analyzed. In view of the difficulty in nomenclature of tumors of the spinal cord, the terminology was confined to an accepted classification, and the microscopic examination was made by means of frozen sections stained with hematoxylin and eosin.

Of 312 cases analyzed, 223 tumors were found which did not involve the spinal cord except by compression; these were classified as extramedullary, and were divided again into 156 intradural and 67 extradural tumors. There were also 89 tumors which involved the spinal cord and were classified as intramedullary.

Included in the group of 67 cases of extradural tumors compressing the spinal cord were lesions arising from bone, intervertebral disks, extradural fat, spinal nerves, and blood vessels, as well as unsuspected metastatic malignant lesions. A preoperative diagnosis of bony extradural lesion may often be made by roentgenologic examination; likewise, it is possible to make a presumptive diagnosis of metastatic malignant lesion when the primary lesion can be determined.

The intradural extramedullary series of

tumors comprised the largest group, and fortunately carried the most favorable prognosis. These lesions take their origin from the fibroblastic structures of the meninges and the vessels of the meninges, or they are projected into the subarachnoid space from without the dura or from within the spinal cord. The 2 types of tumor predominating are the endothelioma, or meningeal fibroblastoma, and the neurofibroma. In this series, about half of the intradural extramedullary tumors proved to be endotheliomas, and about a third were neurofibromas.

In analyzing the intramedullary lesions, 89 cases were reviewed. Tissue was available in only 62 cases. Tumors arising from the cord and comprising the group of gliomas predominated, but also benign encapsulated tumors which were capable of complete removal were found. In a number of cases in which tissue was not removed, palliative relief was obtained by means of decompression, coincidental with laminectomy.

In view of the fact that laminectomy can be performed with minimal risk, exploration can be carried out in many atypical cases of compression of the spinal cord for palliative as well as for diagnostic purposes. In a very high percentage of cases of compression of the spinal cord, a differential diagnosis between inflammatory and neoplastic lesions can be ascertained preoperatively by means of roentgenologic examination, complete neurologic study including examination of the cerebrospinal

fluid, and the use of lipiodol when indicated. But the exact pathologic nature of the underlying cause of compression is rather difficult to determine, and this pathologic analysis furnishes evidence of the multiplicity of lesions that can be encountered at operation.

#### TABULATION

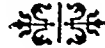
##### TISSUE CHANGES THAT CAUSE COMPRESSION OF THE SPINAL CORD

Extramedullary	Arch of vertebrae	Hypertrophic osteitis Benign giant cell tumor Osteoma Chondroma
	Body of vertebrae	Carcinoma, metastatic Osteosarcoma Benign giant cell tumor
	Intervertebral disk	Chondroma Fibrochondroma Fibromyxochondroma
Meningeal	Extradural fat	Lipoma Lymphosarcoma Fibrosarcoma, metastatic Hypernephroma, metastatic
	Spinal nerves	Neurofibroma
	Blood vessels	Hemangioma Hemangioendothelioma
Medullary	Extradural	Tuberculoma Fibroma Pachymeningitis
	Intradural	Endothelioma (meningeal fibroblastoma) Hemangioma Neurofibroma Cystic arachnoiditis Varicosity of vessels
	Cord	Fibroma Ependymoma Glioma Angioma Endothelioma Fibrolipoma Hemangioma
	Intramedullary	Cysts, including syringomyelia Abscesses Malignant metastatic growths

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\*Continued from p. 265.

# PRACTICAL PROCTOLOGY\*

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NEW YORK

**P**ROCTOLOGY occupies a prominent place in the Biblical, ancient and modern history of medicine. Until recently the treatment of rectal affections rested largely in the hands of ignorant advertising itinerants because of the brutal and unsatisfactory manner in which they were handled by regular physicians and surgeons.

During the last three decades rectal specialists have perfected their technique to a high degree so that today anorectal affections are accurately diagnosed and quickly prepared and operated upon under local anesthesia without confining the patient to bed for more than a few days or causing the agonizing postoperative pain that formerly followed operations for hemorrhoids, fissures and fistulae. As a result of these advancements quacks are becoming extinct and anorectal diseases are being more frequently and intelligently handled by the regular profession.

Hemorrhage, incident to vomiting, straining, and pulling off of dressings after ether, is avoided by infiltration anesthesia and severe postoperative pain is prevented by substituting thin drains for thick packing and mild stimulants (silver nitrate 6 per cent or ichthyol 15 per cent) for stick silver and copper in the treatment of wounds. Hemorrhage is also avoided by the use of mineral oil to soften and lubricate stools instead of cathartics which liquefy them to the patient's discomfort.

General anesthesia may be employed when operating for cancer, stricture, deep abscesses, complicated fistulae, high polyps, imbedded foreign bodies, complete incontinence, extensive procidentia recti, abdominal complications and surgical procedures where [the nature and extent of cutting cannot be determined beforehand.

Spinal anesthesia is effective in these conditions but sacral or caudal anesthesia should be discarded since all minor rectal operations can be painlessly performed under infiltration anesthesia in less time than it takes to desensitize the parts in the manner described.

*Local Anesthesia:* The writer has employed infiltration anesthesia for twenty-five years and performed over 15,000 operations under it without a single serious complication or dangerous postoperative hemorrhage.

Local anesthesia is always effective and obtained in about ten seconds when the operation field is distended with the solution until white with or without adrenalin. Different drugs are useful but novocaine 1 per cent is satisfactory because it is reliable and found in all operating rooms. Quinine and urea are contraindicated since when not followed by sloughing they cause induration of tissues and slow healing.

Infiltration (pressure) anesthesia is linear for fistulae and skin incisions but made directly into the parts when hemorrhoids, fissures, tumors, polyps and anal papillae are removed; one or more injections are employed depending on the operation.

The writer employs local anesthesia in the following cases which constitute more than 80 per cent of anorectal diseases: Internal protruding, bleeding, capillary, combination, external, cutaneous and thrombotic hemorrhoids; fissures, ulcers, single and multiple, superficial long and short fistulae; procidentia recti (first and second degree), cryptitis, hypertrophied anal papillae, marginal, submucous and ordinary ischiorectal abscesses; polyps, low strictures, foreign bodies, constipation incident to sphincteralgia, hypertrophy of

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the levator ani muscle or narrow anal canal, incipient anal epithelioma, perianal cysts, tumors and condylomata; pruritus ani, sacral dermoids and fecal incontinence.

Under infiltration anesthesia the writer has often performed exploratory celiotomy, colostomy, appendicostomy, cecostomy, ileostomy, sigmoidopexy, colopexy and other abdominal operations including breaking up of adhesions, straightening Lane's kinks, dividing Jackson's membrane, draining an obstructed bowel and closing appendiceal and cecostomy openings following the cure of chronic ulcerative colitis.

A 2 oz. metal syringe having a goose-neck attachment and strong screw-on needles of variable lengths are required in the successful production of local anesthesia.

*Hemorrhoids:* All types of hemorrhoids are operated on under local anesthesia without adrenalin or divulsion of the sphincter which can if desired be accomplished by superficial infiltration of the perianal region.

Internal hemorrhoids are separately exposed through an anoscope having a slanted end, injected until distended and white, drawn down with blunt forceps, dissected upward, ligated at the upper attachment of the pedicle and excised, each tumor in turn being treated likewise.

The ligature is the operation of choice because it is quickly performed and post-operative hemorrhage is rare. Redundant skin is removed with the hemorrhoid or separately by a v-shaped cut pointing in the rectum. Should there be oozing bleeding is controlled by the insertion of a vaseline covered gauze plug through the anoscope.

External thrombotic tumors are infiltrated and incised and the clot evacuated following which skin edges are excised and the wound is packed with a gauze pledget to control bleeding. Cutaneous piles and skin tabs are individually injected, caught with forceps and removed with scissors.

These operations are painless except for a twinge from inserting the needle; post-

operative pain is nil when morphine grain  $\frac{1}{4}$  is given hypodermically fifteen minutes previous to operation and repeated later should pain recur.

Hemorrhage, which is rare following local anesthesia operations, is prevented by a wedge-shaped compress snugly held in place by a tightly adjusted T-binder. Polyps are ligated and excised following novocainization at their attachment to the mucosa. Hypertrophied anal papillae are caught and snipped off with scissors and inflamed crypts are hooked up and excised following infiltration without the patients going to the hospital.

Anal fissures, the result of a narrow anal canal and constipated stools, the most painful of all anorectal diseases, are characterized by their location in the posterior commissure, slit-like appearance, accompanying spasm of the levator ani and sphincter muscles that induce excruciating pain during and following stool and blood streaks upon the feces. Occasionally they are healed by restricting the diet, softening stools with fruits, oils and laxatives and applying silver nitrate 6 per cent or ichthyol 15 per cent. The practice of cauterizing fissures with stick silver or copper is to be condemned because of resulting terrific pain and delayed healing. Sphincteric divulsion gives only temporary relief and should be abandoned.

The writer's anal canal splitting operation is curative and prevents recurrence, since it arrests muscular spasms, widens the anal canal and provides for free evacuations. His technique consists in making a  $1\frac{1}{2}$  in. incision in the posterior median line through the fissure, perianal skin (to insure drainage), sphincter and fibers of the levator ani muscle following linear novocaine infiltration. Subsequently following swabbing a gauze drain is daily inserted in the wound which stimulates healing and leads to widening of the rectal outlet.

*Anorectal ulcers*, which are superficial, irregular-shaped and accompanied by a discharge, are often cured with ichthyol

5 per cent enemas, touching them individually with silver nitrate 8 per cent, and procuring semi-solid evacuations with oils.

tion of a probe to define the tract and openings; then following removal of the probe and introduction of a curved probe

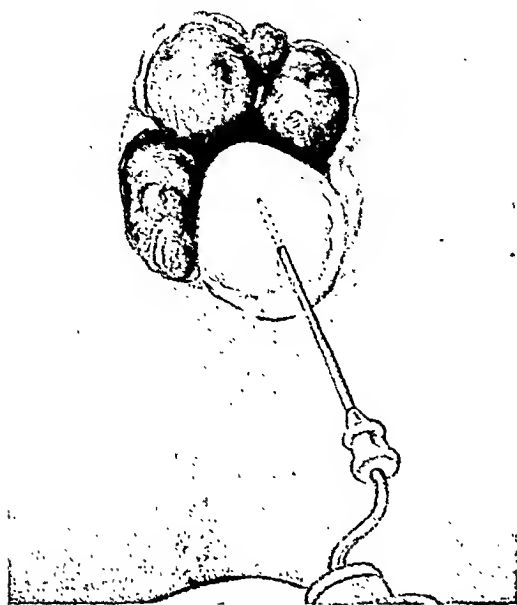


FIG. 1. Method of infiltrating extruded hemorrhoids preceding dissection from their base, ligation and amputation.

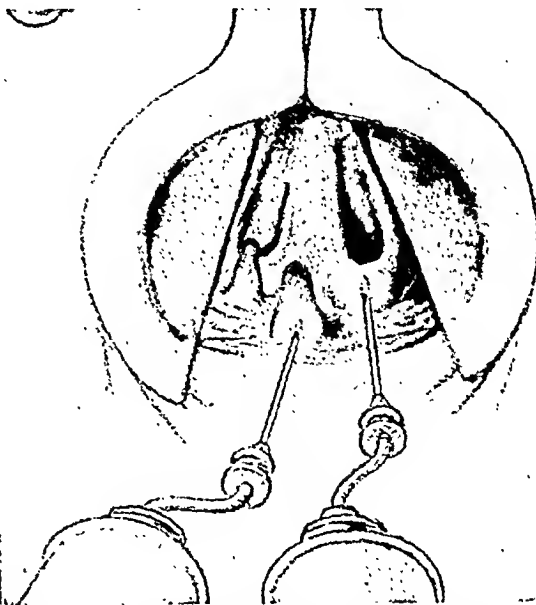


FIG. 2. Papillae and inflamed crypts are caught and excised following infiltration.

When ulcers are deep and sensitive they are curetted under local anesthesia and irritable muscles are divided posteriorly following which the wound is cleansed and drained as after fissure operations. Colonic ichthyol 5 per cent or silver nitrate (grains 8 to 1 qt.) irrigations are prescribed for high lesions when colitis is a complication.

Subcutaneous, submucous and other minor perianal abscesses are freely incised, curetted and drained under novocaine, but deep extensive ischio-rectal, perirectal and pelvirectal pus collections are taken care of under gas oxygen since infiltration anesthesia is painful and unsatisfactory.

Fistulae are treated by division under infiltration anesthesia since excision usually fails and the injection method is useless. General narcosis is employed for complicated fistulae but local anesthesia has proved satisfactory in 80 per cent of the writer's operations whether sinuses were single or multiple. The technique is simple and consists in linear infiltration of skin and overlying tissues following introduc-

pointed steel groove director the sinus is divided which may or may not necessitate severing the sphincter depending on whether or not the tract runs below it or just beneath the mucosa and skin.

The sinus is easily dissected out but this is unnecessary since a cure follows simple incision when the wound is daily swabbed and drained (not packed). Postoperative fecal incontinence is rare when a gauze pledget is daily inserted instead of tight packing which destroys granulations. It keeps the muscle ends apart and leads to the formation of sulcus through which feces involuntarily escape. Multiple sinuses are in turn divided but the main tract entering the rectum posteriorly in the median line is incised last. Gauze is a sufficient stimulant but when healing is sluggish mercurchrome 2 per cent, silver nitrate 6 per cent or ichthyol 15 per cent applications are employed, stick silver and copper being used only to destroy exuberant granulations. Tuberculous fistulae are curable in a similar manner except when the

patient's vitality is markedly reduced by phthisis.

*Pruritus ani*: Medication, sera, roentgeno-



FIG. 3. Showing local anesthesia division operation for fistulae.

therapy and the subcutaneous injections of alcohol, quinine and urea or hydrochloric acid are unsatisfactory and best results are obtained from the undercutting operation described later which liberates entangled nerve ends.

By the use of a long needle perianal skin and anal mucosa are infiltrated with novocaine; through four right angle  $\frac{1}{2}$  in. incisions made equidistant to each other and 1 in. from the anus, blunt pointed scissors are introduced and all nerves are severed from the involved skin area and anal canal mucosa; finally gauze drains are inserted through the four original incisions. Proctitis, hemorrhoids, ulcers or other conditions causing a discharge must be corrected, otherwise pruritus may recur.

*Prolapsus ani* (first and second degree) is corrected by seizing, ligating and amputating several areas of mucosa following novocainization (Fig. 5). This causes adhesion of mucosa to the muscular coat and subsequent shortening of the rectum through resulting cicatrices. An elaborate plastic operation is required for third degree procidentia recti.

*Rectal Constipation*: Delayed and incomplete evacuations are frequently due to anorectal lesions, viz.: fissure, hemor-

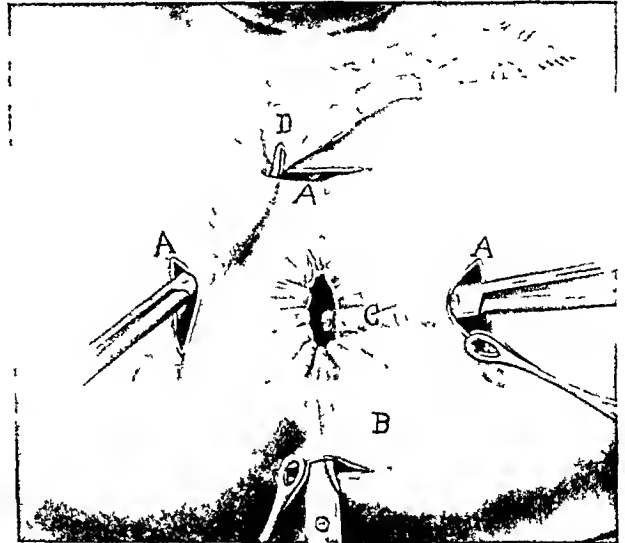


FIG. 4. Technique of Gant's local anesthesia undercutting operation for pruritus ani.

rhoids, fistulae, hypertrophied papillae, etc., which block the bowel or cause sphincteric spasm the treatment of which has already been outlined. Most often rectal constipation is induced by hypertrophy of the rectal valves, levator ani or sphincter muscles or narrowing of the anal canal. Rectal valves are divided with the writer's valve clips. When obstipation is due to thickening or spasms of the sphincter or levator ani muscles, or a contracted lower rectum, it is corrected and comfortable stools procured by infiltrating the rectal wall posteriorly, in the median line, and splitting the anal canal and muscles with a blunt pointed bistoury, and treating the wound as after fissure operations, a procedure which leads to permanent widening of the anal canal and regular movements.

Perianal cysts, tumors and sacral dermoids (pilonidal cysts) are destroyed under local anesthesia by infiltrating overlying integument, dissecting them out or incising, curetting and draining cavities where they have become infected; but unless the entire sac and contents are removed a second operation will be required.

Cicatricial and other strictures located



in the lower 3 in. of the rectum may be divulsed or preferably divided at several points following novocaine infiltration but

in over 90 per cent and all patients rapidly gained in weight and morale. In 10 per cent not cured but greatly improved

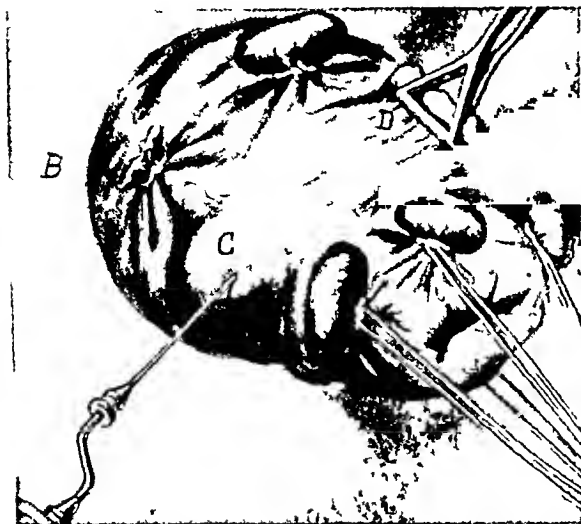


FIG 5. Writer's local anesthesia multiple ligature operation for procidentia recti.

higher stenoses necessitate general narcosis and excision or colostomy.

*Ulcerative Colitis, Appendicostomy and Cecostomy:* Frequent fluid evacuations containing mucus induced by gastrogenic, neurogenic, and gastroenterogenic disturbances come within the domain of general medicine but when the colon and rectum are extensively ulcerated, the result of catarrhal, tuberculous, amebic, balantidic, helminthic, flagellate, parasitic, gonorrheal or syphilitic infection and the patient is exhausted because of indigestion, frequent evacuations, abdominal pain, gas distension and hemorrhages, the case is surgical since dieting, medication and rectal irrigations benefit the patient only temporarily. In such cases colonic organisms aggravate the ulcerative process in all cases.

Patients afflicted with severe chronic colitis are anemic, nervous, show a marked loss in weight and are discouraged because of having been treated by different physicians without relief. These sufferers readily respond to appendicostomy and cecostomy plus through and through colonic medicated irrigations and in more than 300 cases treated by the writer a cure was obtained



FIG. 6. Writer's stab-wound appendicostomy and subsequent colonic through and through irrigation.

infection was due to tubercle infection complicated by phthisis, *Balantidium coli* or some obscure complication.

Appendicostomy and cecostomy openings were quickly, painlessly and safely closed extraperitoneally in the office or hospital by ligating and amputating the freed appendiceal stump or fistulous tract at its cecal juncture following infiltration of the skin and deeper structures with novocaine and approximating wound edges with interrupted stitches.

Subsequent to appendicostomy and cecostomy patients are permitted a regular diet excepting raw fruits and rough vegetables and advised to partake freely of baked potatoes. Through and through colonic quart irrigations of ichthyol 5 per cent are employed twice daily unless stools contain considerable blood when silver nitrate irrigations (5 grains to a quart) are employed until bleeding ceases. Bowel flushing is continued until stools are normal and the patient regains his digestion morale and weight when the appendiceal or cecal opening is closed.

Appendicostomy and cecostomy are pref-



erable to enterostomy and colostomy because the latter are not effective and subject the patient to the annoyance of an artificial anus. Appendicostomy and cecostomy are dependable but appendiceal irrigations are preferable since appendicostomy is less often complicated by superficial infection and is employed unless appendectomy preceded the colitis. The mortality was 2 per cent in 200 and nil in the last 100 cases of appendicostomy and cecostomy performed by the writer.

The technique of appendicostomy is simple, viz.: through a right rectus incision the appendix after being located is brought out through a stab wound (Fig. 6) and sutured to the skin following which it is amputated and the irrigating catheter introduced. In cecostomy after exposure through a similar incision the cecum is punctured, a catheter is inserted and attached with a purse-string suture and the wound closed with interrupted linen sutures.

In both operations the cecum is adhered to the parietes by suspension sutures tied across rubber tubings on either side of the appendiceal stump or catheter. This procedure is important since it permits extra-peritoneal closure of the irrigating aperture under local anesthesia when the patient is well.

**Anorectal Cancer:** Eighty per cent of anorectal cancers involve the rectum of which 75 per cent are in the bowel and 5 per cent at the anus. Epitheliomas (squamous-celled) attack the anal margin while carcinomas (cylindric-celled) are located in the rectum proper and may be encephaloid (soft), scirrhus (hard), colloid (gelatinous) or melanotic (pigmented).

Epitheliomas begin as wart-like excrescences with inflamed ulcerated edges and cause constipation, excruciating pain, sphincterismus, offensive discharge, painful defecation and slight loss in weight but rarely cachexia.

Carcinomas are differentiated by their hard lumpy feel, rapid loss in weight, cachexia, offensive mucopurulent secretion

containing blood, constipation, straining and a feeling as if something was left in the bowel after defecation. These tumors are readily diagnosed by touch and inspection through the proctoscope.

**Treatment:** Suffering is mitigated by regulating diet and stools, alleviating pain with opiates and cleansing the bowel with irrigants. Deep x-ray applications often minimize pain and sometimes cause slight shrinkage of neoplasms but otherwise are unreliable.

Radium, occasionally effective in anal epitheliomas (skin) markedly increases pain when introduced into the rectum. One case of carcinoma involving the lower sigmoid was cured by projecting seeds into the tumor, but radium however used by the writer has in all instances failed to cure rectal carcinoma.

**Operative Treatment:** Rectal malignancy is a surgical disease and must be removed with adjacent fat and infected glands. Colostomy is employed to prevent obstruction and in excision cases where growths are in the upper sigmoid or colon and resection is impracticable. Good results follow radical operation and mortality is less than 5 per cent when movable tumors are removed by perineal excision as described later.

Cancers involving the lower sigmoid and rectum have been removed by perineal, sacral, vaginal and perineo-abdominal excision but the writer employs only the first-named.

**Perineal Excision:** In 50 recent cases perineal excision was employed exclusively and little difficulty was encountered in extirpating high and low rectosigmoidal growths without removal of sacral or coccygeal segments or establishing an artificial anus. In 80 per cent operation was performed in less than half an hour and the bowel brought down and sutured in the anal region causing but slight or no shock.

Briefly described the following is the technique employed by the writer:

**First step:** Skin and rectum having been swabbed with iodine the anus is closed by a

linen purse-string suture. *Second step:* The terminal rectum is freed by perianal incisions carried through skin and subcutaneous fat and the writer's safety pin retractor is inserted or the bowel is clamped with heavy curved pressure forceps which serve for manipulative purposes.

*Third step:* Perirectal and the levator ani muscles are hooked up with finger and severed with blunt scissors which loosens the lower 2 in. of the rectum. *Fourth step:* The bowel is freed anteriorly from the prostate or vagina by blunt dissections. *Fifth step:* Higher perirectal muscles, ligaments and fascia are in turn divided using finger tip as guide and scissors dissections carried towards the bowel anteriorly and laterally and from the gut posteriorly (to avoid vessels). *Sixth step:* Having controlled bleeding with boiling hot water gauze packs and ligatures, encircling peritoneum is severed in similar manner. *Seventh step:* The bowel is drawn downward from 3 to 15 inches as high restraining fascial and ligamentous bands are severed. *Eighth step:* The gut is amputated with cautery ligated about 1 in. rubber tubing and anchored by linen sutures at the anal site following the introduction of anterior and posterior drainage packs. *Ninth step:* Wound edges are approximated with interrupted linen sutures. *Final step:* A thick firm gauze compress is placed over the wound and held in place by a snugly adjusted T-binder through which the rubber

tube projects that gas and feces may escape without soiling the wound.

Postoperative treatment consists in elevating foot of the bed, restricting diet to liquids and prescribing opiates to tie up the bowel and keep the patient comfortable.

The chief advantages of perineal over other excision procedures are: only a few moments are required, shock is almost nil owing to quick removal and method of controlling hemorrhage, the anus is located at the normal site, convalescence is shorter, the patient has almost complete control over solid stools, disgusting features of colostomy are avoided, pain from bone stumps is prevented and postoperative sequelae are rare.

Operative results for rectal cancer are remarkably good because metastases form slowly and in the writer's cases cures have occurred as frequently after perineal as after the combined operation. In 300 cancers of the lower bowel the sigmoid or descending colon was involved in only 5 per cent and following 200 rectosigmoidal excisions recurrence was observed in the sigmoid in but 2 cases.

From this experience the writer is convinced the combination operation with colostomy should be abandoned in favor of perineal excision as it is evident sigmoidomesocolonic glands are seldom responsible for recurrence here though enlarged (inflamed) at time of operation.



# HYPERPLASTIC PROCTITIS

(RECTAL GRANULOMA)\*

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PHILA., PA.

**B**UT few cases of hyperplastic proctitis have been reported; none were found in the American or English literature. Because of this, and the possibility of mistaking it for carcinoma, the following case is of interest:

*History:* Male, aged sixty, baker, married, entered Alexian Brothers Hospital, Chicago, on the service of Dr. Edward F. Hess, February 23, 1928, complaining of malaise, anorexia, pain in the left inguinal region and rectal trouble. This was a dull ache in the lower rectum, soreness and at times a dull pain when bowels moved, urgency, a blood-tinged purulent discharge which seeped through anus and occasional incontinence for liquid feces.

*Past History:* Married, wife living and well. No children. Previous illness: no significant previous diseases. Denies lues and gonorrhoea. Has had no operations. Health has been vigorous for his age until now.

*Proctoscopic Examination:* February 23, 1928. The mucosa of the last 2 in. of the rectum is replaced by a granulomatous tissue except for an irregular strip from  $\frac{3}{4}$  to  $\frac{1}{2}$  in. wide of normal mucosa in the left lateral quadrant. The granulation tissue is paler than the normal mucosa above and is dotted with small red dots less than a millimeter in diameter. Thick yellow pus partially covers the granulations; this pus seeps through the anus, necessitating the wearing of a small pad. The granulating surface of the last 2 in. of the rectum is for the most part smooth but with nodular areas in places and especially at the upper (cephalic) edge of the involved area it is raised 3 to 5 mm. above the adjacent normal mucosa and has a nodular, polypoid configuration. To briefly describe the appearance: It is granular, paler than the normal mucosa, has an elevated irregular, rather nodular edge and is coated with thick yellow pus and mucus. The red dots (capillaries) are not conspicuous; swabbing with cotton brings them out. On digital examination the tissue feels slightly firmer than the normal, except at the upper edge which is distinctly

firmer. The scar of an old laceration can be felt through the anterior midline of the anus and up an inch in the rectum.

*Present Illness:* He states that he had been drinking New Year's Eve and that he wandered into a negro neighborhood. While passing a house he was seized by a big negro and an accomplice who dragged him inside and subjected him to sodomy. (Note: This may be the fanciful story of a pervert, but he maintains it.) The anus was sore afterward and when the bowel moved, painful; about two weeks later he noticed a discharge which seeped through the anus and a week after this the left inguinal glands became tender and enlarged. Seven weeks after the attack, February 23, 1928, he entered the hospital with a temperature of 100.8°F., pulse of 68, and respiratory rate of 20.

*Course and Treatment:* During his third week in the hospital a left inguinal gland suppurated and was incised and drained. Cultures from the pus were sterile. The inguinal wound did not heal well under the usual antiseptic measures and presented a rather granulomatous appearance. Because of the possibility of granuloma inguinale 5 intravenous injections of 1 grain of tartar emetic were given on alternate days. A biopsy report on the tissue from the inguinal lesion was: Infectious granuloma, not tuberculous. The inguinal condition gradually healed, but that in the rectum showed no improvement. Although repeated blood Wassermann tests and four dark field examinations were negative, the patient was given vigorous anti-syphilitic treatment by Dr. Hess as a therapeutic test. This consisted of 10 intravenous injections of 0.6 gm. neoarsphenamine, an average of 2 a week; 8 intramuscular injections of gray oil and 150 gr. of potassium iodide daily for ten days.

*Laboratory Findings:* Feb. 24, 1928: Blood examination: 4,070,000 erythrocytes, 7000 leucocytes. Differential: polymorphonuclears, 66 per cent small lymphocytes 28 per cent transitionals 6 per cent.

Feb. 10, 1928: Biopsy (Dr. Simonds:)

\* Submitted for publication November 12, 1930.

a. Tissue from inguinal gland: Infectious granuloma, not tuberculous.

b. Tissue from rectum: Ulceration with

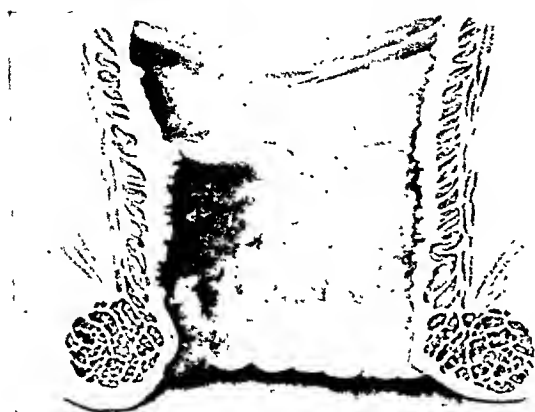


FIG. 1.

granulation with lymphocytes and plasma cells. No evidence of cancer or tuberculosis.

June 2, 1928: Biopsy (Dr. Simonds): Tissue from rectum. Surface squamous and the glandular epithelium in all sections is intact. The growth is composed of fibroblasts and round cells of various types. Diagnosis: Infectious granuloma.

He was discharged from the hospital with the rectal condition somewhat improved, May 4, 1928. In the year and a half since, his general health has been good. The rectal condition has remained much the same for this period, with the exception that it becomes more active for a few weeks in intervals of several months and the entire circumference of the bowel is now involved. In 1929 the granulomatous tissue was deeply fulgurated over the anterior half of the rectum but it promptly recurred and four months later there was no difference from the untreated half. The condition is slowly progressive, it has extended upward 1 to 1½ in. in two years. There is very little lessening of the rectal lumen and no tendency to stricture formation yet. A mucopurulent discharge continues and seeps through the anus, so a pad has to be worn, and occasionally there is incontinence for liquid feces.

On September 30, 1929, a third biopsy was made from the upper edge of the granulomatous surface. The histological findings are as follow:

A navy bean sized piece of soft, grayish pink, colored tissue was submitted for examination.

The sections show a well preserved rectal mucosa which contains hyperemic vessels and is densely infiltrated with lymphocytes, plasma cells, histocytes and leucocytes. The muscularis mucosa is split up by these infiltrations which extend into the deeper tissue where a marked fibrosis and hyalinization are present. The muscularis is apparently replaced by fibrous tissue. The vessels in these portions are dilated, but otherwise normal. The round cellular infiltrations do not show any direct connections to the vessels. There are small groups of large, vesicular cells found scattered in the tissue. The cytoplasm of these cells contains a very delicate pink stained network. The nucleus is round, moderately large and usually somewhat eccentrically located. Special staining for ameba after Jacger is negative. Sections stained with polychrome methylene blue show in the submucosa occasionally large, mononucleated cells containing and surrounded by accumulations of very small round, gram-positive cocci which form sometimes short chains.

The bacteriological investigation of smears and cultures of the mucosa in dextrose bouillon, milk, Loeffler's serum agar and plain agar, showed the presence of gram-positive diplococci and short gram-positive rods. The normal flora of the intestine is mixed with a prevalence of gram-negative forms (*B. coli*). Cultures of excised tissue made by Dr. Ernest Pribram showed gram-positive bacteria.

The Frei test for lymphogranuloma inguinale, for which we obtained the antigen through the kindness of Dr. Frei,<sup>1</sup> was negative.

#### COMMENT

All the attempts to establish a definite etiology for the condition described have failed. The syphilitic origin has to be excluded due to the repeatedly negative Wassermann tests and the negative results obtained with antisyphilitic treatment and the negative histological findings. Granuloma inguinale can be dismissed as the specific treatment with tartar emetic was negative; Donovan bodies were absent in the smear and tissue and the histological structure in our case differs distinctly from that seen in this condition (Fischer and v.

<sup>1</sup> *Fritz. Klin. Wochenschr.*, 4: 2148, 1925.

Gusnar.)<sup>1</sup> There is no evidence that we are dealing with lymphogranulomatosis inguinale as the Frei test, which according to this author is specific, was negative. The extremely prolonged course and the absence of Ducrey's streptobacilli is against a chancroid character of the lesion. There is also no support for a tuberculous etiology present. The rectal condition has therefore to be classified among the rather rare cases of chronic hyperplastic granulomatous proctitis of apparently non-specific

origin. The characteristic feature of this condition in the replacement of the rectal mucosa by granulation tissue which shows but little tendency toward scar formation. The granulation tissue in which islands of surface epithelium may be present, may invade the muscularis and subserosa and may extend in these layers for large distances. Beside this granulomatous type of chronic proctitis there exists also a hyperplastic papillary one of tumor-like appearance (Siegmund).<sup>2</sup>

<sup>1</sup> FISCHER and v. GUSNER. *Beitr. c. patb. anat. u. z. allg. Patb.*, 81: 309, 1928.

<sup>2</sup> SIEGMUND. *Handbuch der Speziellen Pathologischen Anatomie and Histologie*. Springer, Berlin, 1929, 4: 3.



## VASCULAR DISEASES OF THE EXTREMITIES

### III. THERMIC GANGRENE\*†

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THE occurrence of gangrene from exposure to cold is seen much more frequently in temperate zones than in those extremities of the earth where severe cold is always present. This lower incidence where one might expect it to be higher may be due in part to the adaptability of the organism to the environment, but for the greater part it can be accredited to education in prophylactic measures.

#### ETIOLOGY

Death of tissues from exposure to cold may be brought about in 4 ways: (1) reduction of the temperature of protoplasm to a degree and for a length of time incompatible with life; (2) ischemia; (3) reactionary hyperemia with transudation of serum into soft parts to compress the vessels and further cut off blood supply; (4) very rarely, thrombosis.

Factors which predispose to frostbite or gangrene are too numerous to review in detail. An extremity with an already impaired circulation is especially susceptible, but the normal one in an inactive state and clothed with moist socks or shoes may become rapidly frozen through both radiation and direct conduction.

#### PATHOGENESIS

On exposure to cold, the capillary bed and small vessels of the exposed part first dilate to produce an active hyperemia. This is in turn followed by cyanosis which shortly is followed by ischemia produced by vasoconstriction which persists and allows the cells to become further reduced in temperature. Under favorable conditions these changes may occur at temperatures considerably above freezing,<sup>10</sup> but with sufficient exposure to zero degrees centigrade, or below, the fluid elements of the

tissues and, blood may actually become frozen.

A part so exposed and properly treated may escape the formation of gangrene if the reduction in temperature and blood supply has not persisted too long. Not infrequently the institution of improper therapy causes gangrene. Heat too vigorously applied to the affected part favors the production of hyperemia and the transudation of serum into soft tissues which compress the vessels and further interfere with the blood supply to an already injured area.

That thrombosis may occur in vessels of a frozen part is not mentioned by most observers, but its occurrence was demonstrated by dissection in those cases reported by von Winiwater,<sup>1</sup> von Recklinghausen,<sup>2</sup> and Nagelsbach,<sup>3</sup> respectively.

Not infrequently infection plays an important rôle in the production or extension of gangrene when it is permitted to occur in already devitalized tissues.

#### SYMPTOMATOLOGY

Freezing of the tissues may be divided into 3 degrees, which are readily determined by inspection. These are: (1) erythema; (2) bleb or vesicle formation; (3) gangrene.

Upon exposure, the preliminary hyperemia usually gives rise to a prickly sensation, which serves as a warning to the initiated that soon there may follow a stage of vasoconstriction with absolute anesthesia. Explorers and others constantly exposed to severe cold frequently inspect one another for these ischemic, waxy-white patches, which usually occur on the fingers, toes, ball of the foot, heel, ears, nose, or wherever the skin is tightly stretched over bone.

If exposure is terminated early in the

\* Presented before the Surgical Faculty, Tulane University, April 21, 1930.

† I. Arteriosclerotic Disease of the Extremities, and II. Erythromelalgia, appeared in the April, 1931, issue, pp. 32 and 40, respectively.

ischemic stage, there follows an intense reddening of the part accompanied by itching, prickly sensation and swelling. Recovery may follow, or there may develop bluish red, flat swellings or nodular elevations surrounded by a red zone representing chilblains.

If exposure is more prolonged, there results bullae, or vesicles on a reddened or violaceous skin. These contain a clear fluid and on rupture may heal easily or become the seat of an indolent ulcer.

With complete and prolonged freezing of a part, there occurs later, swelling, bluish red mottling or cyanosis, congestion, and persistence of anesthesia. With these manifestations, if circulation is not shortly reestablished, gangrene occurs. Distally, the gangrene may involve deep structures, including bone; but proximally, only the more superficial structures, and at the line of demarcation the skin, are involved.

Areas once frozen are subject to recurrences and following the shortest exposure to cold the sensations of burning or pricking in these areas become prominent.

#### PROGNOSIS

Meyer and Kohlschütter<sup>4</sup> believe that if areas of cyanosis, lividity, and anesthesia persist for a week or more, the part cannot be saved. A prognosis where factors may be so variable must be guarded. When ischemic areas are detected early and treated properly, they usually suffer no permanent damage.

#### TREATMENT

Education in prophylactic measures would do much to lessen the need of treatment. For those exposed to cold, the maintenance of a vigorous circulation and the wearing of loose, warm clothing should serve to prevent freezing. Proper clothing acts as a non-conducting air space between the skin and the outside air. If the clothing, whether it is wool or fur, becomes greasy or wet, the air is displaced from the meshes or hairs, respectively, and it becomes an excellent conducting medium. That grease,

fats, and oils are relatively non-conducting is true; but air is certainly less conducting, and, therefore, the former should never be applied or be allowed to accumulate in clothing and should be used on the skin only when something is required to break the force of a strong wind on exposed parts.

The ideal foot gear is not obtainable. Waterproof shoes retain perspiration and those that permit ventilation allow absorption of water and moisture. Thus it becomes important to constantly inspect the feet in case of undue exposure and to change the socks and shoes immediately on cessation of activities.

The application or rubbing of snow on frozen parts is to be condemned, as it is not rational and may introduce micro-organisms into abrasions produced by its use. Measures to reestablish circulation quickly are undesirable as these produce a hyperemia and transudation of serum which favor mortification.

For primary frostbite the application of dry moderate warmth is desirable. This is probably most conveniently obtained by applying the frozen part to warm portions of the body. Gentle massage is of value in restoring circulation, but great care must be taken not to abrade the skin. Most cases should react to treatment of this sort within several hours.

For more severe cases immobilization and elevation of the affected part are important. If dry warmth cannot be conveniently applied, warm fomentations are satisfactory, provided that the solutions used are isotonic and thus not likely to produce an unfavorable reaction. As manipulations are undesirable, it seems probable that the application of cotton wool and a loose bandage should prove efficacious. If blebs form, these should be opened, but only under aseptic precautions.

The treatment as outlined has been entirely satisfactory in the hands of Mocklin<sup>5</sup> in various polar expeditions. More energetic means have been advocated by various authors. Noesske<sup>6</sup> and Weitig<sup>7</sup> make multiple incisions in order

to relieve impeded venous circulation. Wachtel<sup>8</sup> uses the roentgen ray, Bundschuh<sup>9</sup> combines multiple incisions with production of hyperemia, and others use contrast baths, exposure to the quartz light, etc.

When gangrene occurs, conservatism should be practiced at least to the extent

of waiting for a definite line of demarcation before amputating. If a weight-bearing stump is not to be considered, a spontaneous amputation should be entirely satisfactory. Should infection occur, the resulting septic absorption or extension of the gangrenous area necessitates an early amputation.

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# The American Journal of Surgery

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The American Journal of Surgery is truly independent and enters into no "entangling alliances." It publishes many papers read before the leading surgical societies of the Country, but it is *not* "the official organ" of any organization. Every manuscript is selected by the editors, as worthy of publication—nothing is published merely because "it was read at the meeting."

## EDITORIAL

THIS issue marks the fifth anniversary of THE AMERICAN JOURNAL OF SURGERY under its present publishers. In celebration, we will indulge in the human traits of reminiscence and prediction.

With the coming of the age of efficiency and mass production, the art of soliloquizing has gone largely into the discard as have the "asides" of the theatre. However, with Eugene O'Neil, the Editor will indulge in the old-fashioned pastime and confide to his readers that to publish or not to publish is a question of continual perplexity.

The size of the Journal has grown in the editorial, circulation and advertising departments. Where some years ago, it was a question of wondering from month to month how to fill the next month's quota of pages, the problem has now become a matter of selection.

Gratifying indeed to both Editor and Publisher is the continual stream of material that is coming to us from all parts of the country. Probably, no more sincere compliment could be paid to the Journal than this evidence of a definite desire to gain admittance to its pages.

There is, however, no rose without its thorns and we feel that our editorial sieve needs a finer mesh. It is very flattering to be flooded with manuscripts and it is the course of least resistance to accept most of the material that comes in. But times have changed. We are not going to be "snooty" but we are going to be critical indeed. We have on our staff specialists on every subject and each article will have to pass muster with the men who know the subject best.

It will not be necessary to have a

national reputation to get into the pages of THE AMERICAN JOURNAL OF SURGERY. In fact, we hope to have a hand in the making of some reputations in the future. But high standing in his community will be a *sine qua non* for the acceptance of any author's paper. The man of good standing who has really something to say and says it well, and in the fewest possible words, will have his material published promptly. The man who simply rehashes old material and the man who is writing to advertise himself will, as far as possible, be eliminated from these pages.

As we are not infallible, we ask the

cooperation of our readers. If you feel that some article should not have been published, write us about it so that we may be guided by your suggestions.

THE AMERICAN JOURNAL OF SURGERY feels that it holds an unique position in that it is absolutely independent of all outside influences. It can accept or discard what it pleases without having to consider organization politics in any way. Our only bosses are our subscribers. We want to serve their interests and, with their help, we hope to make a great success of it.

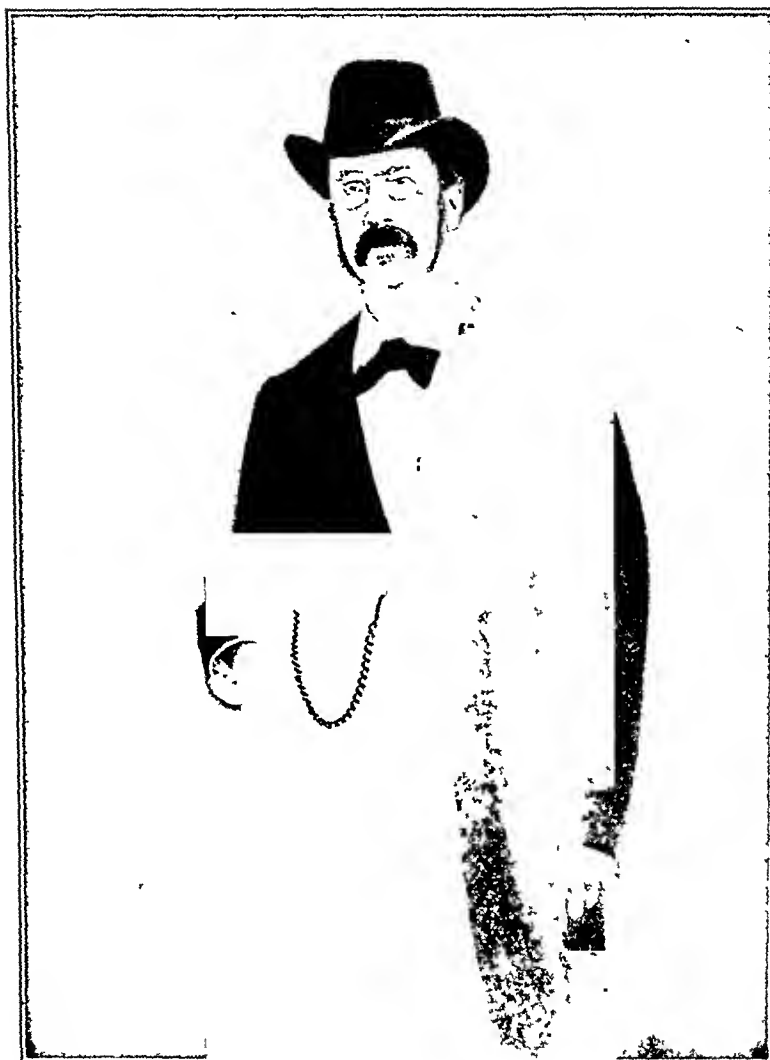
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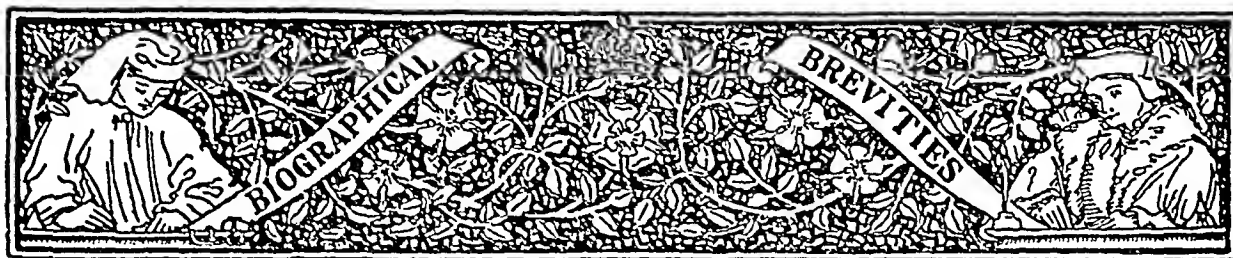
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WILHELM HIS

[1831-1904]



## “HIS’ ZONE”

TO physicians His’ name is associated with several eponyms: His’ bursa, canal, rule, space. His son is known for such eponyms as His’ band or bundle, and His’ spindle. Hiss’ stain was named after Philip Hanson Hiss, a New York bacteriologist who died in 1913.

Wilhelm His was born in 1831 at Basel, Switzerland. He will be known as one of the greatest embryologists of the nineteenth century. He did the best work of his day on the origin of tissues and the serial and morphological consideration of embryonic and adult organisms.

He came from a noted and distinguished family and had the advantages of an excellent education. His teachers were Johannes Müller, Robert Remak, Virchow, and Kölliker. His was professor of anatomy at Basel from 1837 to 1872. Through the influence of Carl Ludwig, he was appointed to the same chair at Leipzig. He kept this position the rest of his life.

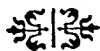
He did important work on the normal and pathological histology of the cornea, the structure of the thymus glands, and the lymphatic vessels. He illustrated the last with wonderful plates. In 1865 he published a great academic program, “On

the Tissue-layers and Spaces of the Body.” In this he introduced a new classification which is still in use. He pointed out that all serous spaces arise in the mesoderm and are lined with the special membrane which “His called endothelial.” His epic monograph on the embryology of the chick appeared in 1868. During 1880–85 his “Anatomie menschlicher Embryonen,” in which the human embryo was studied as a whole, came out.

His was an artist of skill and a photographer of parts. He sought to teach his pupils by means of microphotography, lantern slides, and models. In 1866 he invented a microtome, which led him to the idea of graphic reconstructions of the embryo in two and three dimensions. The His-Steger models, now common in many anatomical museums, are permanent evidence of his success in demonstrating morphological relations in dimensional space.

His founded several societies but no school. His pupils, Franz Keibel and Franklin P. Mall, carried to a conclusion his work on the anatomy of the human embryo.

Wilhelm His died in 1904.





[From Fernelius' *Universa Medicina*, Geneva, 1679.]

# BOOKSHELF BROWSING

## THE STORY OF THE DEVELOPMENT OF CHOLECYSTOGRAPHY\*

EVARTS A. GRAHAM, M.D.

ST. LOUIS, MO.

WHEN I was asked by Dr. Alvarez to give the first Walter C. Alvarez Lecture before this society on the proposed title of "The Story of the Development of Cholecystography" I felt embarrassed about accepting the invitation. The chief reason for the embarrassment was that I felt that I could hardly discuss this matter frankly without perhaps conveying the idea that I had an exaggerated impression of the importance of cholecystography in comparison with other medical discoveries. Dr. Alvarez, however, was so insistent and advanced such excellent arguments in favor of my presenting an informal account of the various things which led up to the development of cholecystography that I finally consented. My reluctance to accept the invitation was in no way concerned with any lack of appreciation of the high honor which has been accorded to me in being able to be the first to occupy the distinguished position of Alvarez Lecturer. I am one of many who have a very great admiration for the remarkable accomplishments which Dr. Alvarez has achieved in changing our thoughts and ideas about the physiology of the alimentary canal. I am also one of many who have been greatly impressed

by the splendid achievements of this society and of its many distinguished members. Accordingly I, a mere surgeon, feel great humility in being selected to stand before this group of men to initiate a long line of lectures which will be given in the future by many of the most prominent men in the medical profession.

Probably the real origin of my interest in cholecystography was a more extensive training in chemistry than was usual for members of the medical profession and especially for a surgeon. With a desire to be able to appreciate better the rapidly developing chemical ideas which were coming into medicine, and with a hope that a better knowledge of chemistry might enable one to advance the science of medicine, I gave up my small surgical practice and spent the years of 1913 and 1914 at the University of Chicago in the study of chemistry. The time so devoted was fruitful to the extent that it enabled me to think somewhat in chemical terms and thus to take advantage of the possibilities of the application of some relatively simple chemistry to the problem of the improved diagnosis of gall-bladder disease.

It is difficult to recall exactly how the idea of the possibility of visualizing the

\* First Alvarez Lecture. Read at the 33d Annual Meeting, American Gastro-Enterological Association, Atlantic City, May 5-6, 1930.

gall bladder by the use of phenolphthalein derivatives presented itself. On several occasions a former member, the late Walter Mills, and I had spoken of the desirability of visualizing the gall bladder in some manner comparable to the visualization of the stomach and other parts of the alimentary canal. No satisfactory method, however, suggested itself until suddenly one evening, in the winter of 1922, the idea occurred to me that since Abel and Rowntree had demonstrated the fact that the chlorinated phenolphthaleins are excreted almost entirely through the bile it might be possible, by substituting for the chlorine atoms other atoms which would be opaque to the x-ray, to obtain a shadow of the gall bladder.

Acting on this suggestion I began to consult catalogues of various manufacturing chemical firms to see if I could obtain some phenolphthaleins containing bromine or iodine atoms which were already prepared. If I had been unable to obtain any from the manufacturers I intended to attempt the preparation of some of them myself, or to have them made under my direction. However, I was able to obtain some of the free acid of tetraiodophenolphthalein from the Eastman Kodak Co. This was advertised in a list of various indicators. After receiving the material I turned it over to Warren Cole, in July, 1923, and asked him to inject it into some animals to see if he could visualize their gall bladders with it. Dr. Cole had just completed serving his residency in surgery at the Barnes Hospital and had become a member of the department as an assistant in surgery. Before injecting the material into dogs we converted it into the sodium salt because the free acid was naturally less soluble than the sodium salt. Six dogs were injected intravenously, and x-ray photographs were made of the gall bladder regions in all of them at frequent intervals after the injection. In five of the dogs no shadow was obtained, but fortunately a faint shadow was obtained in the sixth one. At first we were at a loss

to understand why we had obtained a faint shadow in one dog but none at all in the other five animals. The idea then occurred to us that the reason for the failure was probably due to the fact that the animals were not fasting and that, therefore, the injected substance was not staying in the gall bladder for a long enough time to be concentrated and, therefore, to make a shadow. From the standpoint of the future development of cholecystography we often feel grateful to that one dog which cast a shadow, probably because he was accidentally given no food. If we had failed to get a shadow in all of these animals we probably should have abandoned the whole idea as a fruitless one. It is curious on how fragile a thread the destiny of some events hangs. When we came to investigate the matter we found that, as a matter of fact, through some mishap the animal keeper during the time of the experiment had for some reason neglected to feed the one dog on the morning of the injection but he had fed all of the others. Greater efficiency on the part of the animal keeper would doubtless have resulted in a complete failure of our experiment and, therefore, we would have given up the whole idea. Sometimes efficiency can be a curse.

With the clue that the failure to cast a shadow was due to the presence of food in the stomach and duodenum it was then a relatively simple matter to determine that we could obtain shadows in almost every instance in our experimental animals if we were careful to make the injections during a fasting period. Problems of dosage then came up and it was necessary to make a large number of injections in order to determine what would constitute a safe dose for the human being. At about this time Glover H. Copher, another member of the Department of Surgery, was added to the group conducting the investigation. The problem was particularly complicated because of the fact that in several instances our experimental animals died after receiving injections which were considerably

smaller than those which had been given to other animals that survived. There was also present before us the well known fact that organic iodine compounds are in general much more reactive than their bromine homologues. This fact made us turn hopefully to the bromine compound, although of course we could predict that the dose of it required to give a shadow of comparable density would be larger than that required for the iodine compound because of the greater atomic weight of the iodine. Accordingly we enlisted the services of the Mallinckrodt Chemical Works of St. Louis who very generously put at our disposal one of their chemists to make a large number of preparations for us. We were eager to try various bromine and iodine substitution products, not only of phenolphthalein but also of other substances which might have possible advantages. We were also interested in knowing whether a more complete saturation of the phenolphthalein molecule with iodine or bromine such as, for example, an octaiodo compound instead of a tetraiodo compound might have greater advantages because of the much greater amount of iodine contained in the molecule. At all events the Mallinckrodt Chemical Works finally supplied us with an exceptionally pure product of the sodium salt of tetrabromphenolphthalein. We injected this material into animals and found that we got good shadows of the gall bladder with much less toxic effects, in spite of the larger dose required, than we had previously obtained from the use of the tetraiodophenolphthalein which we had obtained. This fact made us feel that for the time being it would be safer to use the bromine compound for human beings than the iodine product.

Up to that time our only idea in visualizing the gall bladder had been to introduce something into it which would visualize any contained stones or deformities of the organ. A colored woman in the Barnes Hospital who presented a very characteristic clinical picture of gallstones seemed

to present satisfactory conditions for the first trial in the human. We carefully calculated what the proper dose of the substance would be if injected into her and we gave her the calculated amount of the sodium salt of tetrabromphenolphthalein. I may say that Mills was much interested in the outcome of this first trial on the human of this material and we all had great hopes that we would be able to get a sharp image of gallstones in the woman's gall bladder. An ordinary x-ray film before the injection of the dye had failed to show any stones. To our great disappointment and consternation the patient showed no shadow at all of her gall bladder after injection, in spite of a series of films which were made. Our disappointment was made more intense by the fact that I operated upon this patient and found a gall bladder which contained many stones of different sizes. It seemed to us, therefore, for the moment, as if our high hopes of improving the diagnosis of gall-bladder disease had been dashed to the ground. Soon, however, the idea occurred to us that since we had been obtaining excellent shadows in our experimental animals, which presumably had normal gall bladders, the reason for our failure to produce a shadow in a markedly diseased gall bladder might be because the diseased gall bladder could not properly concentrate the material which was brought to it. We also, of course, took into consideration the possibility that in the diseased gall bladder there might have been an obstruction of the cystic duct which prevented the entrance of the material into the organ, but in the case in which we had had a failure I had found an abundance of bile in the gall bladder at the time of operation and also no evidence even suggestive of an obstruction of the cystic duct. We were, therefore, forced to believe that a diseased wall in itself might be sufficient to result in non-visualization because of the failure of concentration. This conclusion seemed to be an obvious one to draw from the work of Rous and McMaster on the con-



centrating function of the normal gall bladder.

This conclusion led us to the next step which was to inject some patients who supposedly had normal gall bladders. We were gratified to obtain well visualized gall bladders in two or three such individuals. This result, while gratifying, made it necessary to change our whole conception of the possible applicability of such a test to the patient. For instead of having a method which would with certainty reveal gallstones in the x-ray picture we found that we were, on the contrary, dealing with a method which was more of a functional test of the gall bladder and one which would show the gall bladder most plainly under normal conditions, and not at all in those conditions in which the organ was very badly diseased no matter whether stones were present or not. The recognition of the fact that this new method of visualization of the gall bladder was really a functional test was brought out in most of our early writings on the subject and we were, therefore, amazed to discover how many years were required before there was more or less general recognition of this fact. We have always felt, however, that there were many advantages in being able to test the function of the gall bladder because, after all, symptoms are only an expression of disturbed function. At this time we felt that we were able to predict with some certainty that in order to have a good visualization of the gall bladder certain conditions were necessary. First, the material must get into the blood stream in sufficient amount. Second, it must be excreted by the liver into the bile in sufficient amount. Third, it must get into the gall bladder. Fourth, the gall bladder must be sufficiently normal to be able to concentrate its contents adequately by the absorption of water. If a single link in this chain of events were defective then either faint visualization or non-visualization would occur.

More and more patients presenting different sorts of disturbances of the

biliary tract were injected and the results seemed fully to justify our prediction as to what might be expected from this new method of diagnosis. However, we were not entirely satisfied with the material because in concentrations which would give really striking shadows we sometimes had rather severe reactions. We were, therefore, led to continue a search for a more satisfactory substance. We tried the calcium salt of tetrabromphenolphthalein, instead of the sodium salt. During all of this time we were also engaged in the preparation of many other substances which we thought might have theoretical possibilities of visualizing the gall bladder. In the preparation of these substances, some of which had never been made before, we were greatly helped by the generous cooperation of the Mallinckrodt Chemical Works. In all we tried 48 different substances, of which 13 were shown to visualize the gall bladder. These various substances are listed in our book.<sup>1</sup> Most of these 13 substances had disadvantages of one kind or another.

While making the effort to find some more desirable substance chemists were also engaged in attempting to make a much more highly purified product of tetraiodophenolphthalein than had been commercially possible before this time. They succeeded in their effort and because the iodine compound had many advantages over the other substances which were able to visualize the gall bladder, we returned to the use of the sodium salt of tetraiodophenolphthalein. At about this time Whitaker and Milliken<sup>2</sup> published their article which seemed to indicate that tetraiodophenolphthalein had advantages over tetrabromphenolphthalein. In view, however, of our previous experience in being unable to obtain a product of tetraiodo-

<sup>1</sup> Graham, E. A., Cole, Warren H., Copher, Glover H., Moore, Sherwood. *Diseases of the Gall Bladder and Bile Ducts*. Phila., Lea and Febiger, 1928.

<sup>2</sup> Whitaker, L. R., and Milliken, G. A. Comparison of sodium tetrabromophenolphthalein with sodium tetraiodophenolphthalein in gall bladder radiography. *Surg., Gynec. Obst.*, 40: 17, 1925.

phenolphthalein on the market, which could be confidently assumed to be free from certain impurities which gave rise to toxic effects, and also because Whitaker and Milliken had reported on the use of the material in only one human being, we were unwilling to recommend wholeheartedly a return to the use of tetraiodophenolphthalein for fear that tragedies might occur at the hands of those who might not be familiar with the dangers inherent in an impure product, and who might also be unfamiliar with the difficulties which existed at that time of manufacturing a pure product. For those reasons then we were somewhat slow to recommend for general use a return to tetraiodophenolphthalein. After the manufacture of the tetraiodophenolphthalein had reached such a state that one could count on obtaining a pure product we then directed our attention to the preparation of the isomeric compound which ordinarily goes under the chemical name of phenoltetraiodophthalein. In this compound the four iodine atoms are in a different part of the molecule. Again we were fortunate in being able to obtain a pure preparation and we, therefore, began experiments with the sodium salt of this isomeric compound. We felt that this substance would have the additional advantage in that not only would it visualize the gall bladder in the same way as tetraiodophenolphthalein, but it would also enable one to carry out simultaneously a test of the excretory power of the liver by virtue of the fact that it stained the serum. Our hopes in this respect were fully justified and for several years, therefore, it has been upon this substance which we have relied. Incidentally, we discovered that a slightly smaller dose of this substance is required for visualization than of the tetraiodophenolphthalein. We do not feel that the ideal substance has yet been found and we are still hoping to prepare something which can perhaps be given hypodermically and be free from all toxic effects in the concentrations necessary to use.

The first demonstration of cholecystography before a Medical Society occurred in February, 1924, at the St. Louis meeting of the Congress of Internal Medicine. The first publication on the subject was<sup>1</sup> "Roentgenological Examination of the Gall Bladder. Preliminary Report of a New Method Utilizing the Intravenous Injection of Tetrabromphenolphthalein." The word cholecystography was first employed in the title of one of our papers which appeared in the *Journal of the American Medical Association* on January 3, 1925.

Up to April 15 there had been examined at the Barnes Hospital by cholecystography 3529 patients, of whom 2618 were examined by the intravenous method and 911 by the oral method.

As is well known there have been so many modifications of the method proposed that it has been difficult to become familiar with all of them. Most of these modifications, however, have been discussed in our book on "Diseases of the Gall Bladder and Bile Ducts." It will not be possible for me to refer to them here.

Reference has already been made to the fact that in turning to phenoltetraiodophthalein we hoped to have not only a substance which would visualize the gall bladder but also one which would simultaneously enable us to test the excretory power of the liver, in a manner similar to the Rosenthal method with phenoltetrachlorphthalein. Soon after the beginning of its employment we discovered that patients who had a high retention of the dye were poor risks for operation. We have, therefore, placed a considerable amount of confidence in this method of examining a patient in order to determine his suitability for operation at a particular time. We were able also to find that even when the retention was high and when, therefore, the patient was a bad risk for operation at that time he could become a better risk, with a corresponding reduction in the amount of retention of the dye,

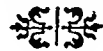
<sup>1</sup> J. A. M. A., Feb. 23, 1924.

by keeping him at rest in bed, by the administration of an abundant amount of carbohydrate, preferably in the form of glucose, a little calcium and generous amounts of fluid. Almost invariably a patient who was a poor risk, simply because of his damaged liver, could be made a good risk for operation by our resorting to the plan of treatment outlined here. The effect, both of the test in guiding us as to operative risk and the plan of preparing patients already mentioned, has had a noticeable result in reducing our operative mortality. For example, during the last three years since we have used phenoltetraiodophthalein for the purpose mentioned, our mortality in the operation of cholecystectomy has been only 0.4 per cent. The mortality in the preceding three years was 6.0 per cent. In other words, our present mortality is only a small fraction of what it was before we began to place some reliance on the excretion of phenoltetraiodophthalein as a means of gauging the operability of a patient.

In addition to the invaluable help given to the working out of the problem of cholecystography by Cole and Copher, the splendid assistance and many suggestions furnished by Dr. Sherwood Moore,

the director of the Roentgenological Department of the hospital, and by Dr. Joseph W. Larimore, a member of the association, were of the greatest possible assistance; in fact it would hardly have been possible for us three surgeons to have been able to work out this problem entirely alone. Not only were the matters of the x-ray technique worked out by Dr. Moore and his associates but also many other valuable suggestions were obtained from both him and Dr. Larimore. It has always been a matter of great personal regret to me that the untimely death of Walter Mills, at the very beginning of the application of cholecystography to the human, prevented his eager and enthusiastic cooperation in the development of the problem.

Finally, I should like to add a few words of appreciation of the kindly and charitable support with which the various members of your organization have received cholecystography as a method of diagnosis. It is seldom that one finds a new procedure taken up so charitably and so enthusiastically as was the reception accorded this particular method by the various members of your organization. For this charitable reception the author now wishes to give his sincere thanks.



## BOOK REVIEWS

**PATHOLOGIE UND KLINIK IN EINZELDARSTELLUNGEN.** By L. Aschoff, H. Elias, H. Eppinger, C. Sternberg and K. F. Wenckebach. Band I DER APPENDICITISCHE ANFALL SEINE ETIOLOGIE UND PATHOGENESE. By Ludwig Aschoff. Mit einem kurzen beitrage über die lymphgefassverhältnisse am menschlichen wurmfortsatz. By Dr. H. Seng. 127 pp., 36 illus., Berlin, Julius Springer, 1930.

This is the first of a new series of modern monographs. Aschoff's study of the appendix from the pathological point of view is based on thousands of cases and, like everything written by the Dean of present-day pathology, will be found extremely interesting.

**A TEXTBOOK OF SURGERY.** By John Homans, M.D. Springfield, Ill., Charles C. Thomas, 1931.

In the preface one reads, "The aim of this book, for which Dr. Harvey Cushing supplied the inspiration, is to record and amplify lectures now given by members of the surgical department of the Harvard Medical School. These lectures . . . are intended to teach the fundamentals and something of the practice of surgery." It fulfils this promise.

Although the contents vary with each contributor the book as a whole is very compact and even. Some of the lectures are monographs on the subject discussed, and in some instances have been published before.

The following men have written chapters: Arthur W. Allen, David Cheever, Edward D. Churchill, Harvey Cushing, William P. Graves, Robert B. Greenough, John Homans, Gilbert Horrax, Daniel F. Jones, William E. Ladd, George A. Leland, Howard A. Lothrop, Richard H. Miller, Edward H. Nichols, Robert B. Osgood, Charles A. Porter, Tracy J. Putnam, Lyman G. Richards, Edward P. Richardson, Channing C. Simmons, J. Herbert Waite, Wyman Whittemore, and Philip D. Wilson.

There is a special bibliographical index and the illustrations are by Willard C. Shepard.

It is a book that has a place in the surgical literature of the day. It covers the surgical field in a satisfying manner and one instantly senses he is reading honest, conservative, solid, and time-tried but modern opinions. It is a

work that well might be in any surgeon's library.

**TECHNIQUE AND RESULTS OF GRAFTING SKIN.** By H. Kenrick Christie M.S. (N. Z.) F.R.C.S. (Eng.) 64 p., London, H. K. Lewis & Co. Ltd., 1930.

This little book on the technique of skin grafting is a splendid resume of the subject. It is based on a series of 30 cases of ulcers of the extremities, including all the types that are to be found with the object of devising a standard method of operative cure for such cases. As all of these cases were traced for two or three years afterwards, the results are of exceptional interest.

**THE CONWAY LETTERS.** The Correspondence of Anne, Viscountess Conway, Henry More and their Friends, 1642-1684. By Marjorie Hope Nicolson. New Haven, Yale Univ. Press, 1931.

These letters are delightful to all those interested in history and they have a special interest to physicians on account of the concrete picture that they give of the patient of that day.

Anne Finch, Viscountess of Conway, had a fever at the age of twelve which was felt to be responsible for the severe headaches which she had for the rest of her life. A brilliant woman, interested in the study of languages, philosophy, mathematics, religion and every form of culture, she came in contact with all of the great men of the day.

She was treated by William Harvey, Sir Theodore Turquet de Mayerne, Lake and Thomas Ridgely and her brother, John Finch. In her letters will be found the complete story of the attempts made to relieve her condition, which was little understood.

These letters are a distinct contribution to the cultural and medical history of England in the seventeenth century and both Miss Nicolson and the Yale University Press should be congratulated on making them up in such splendid form.

**SURGICAL OPERATIONS.** By Sir Frederick Treves, Bart. G.C.V.O., C.B., LL.D., F.R.C.S., and Cecil P. G. Wakeley, F.R.C.S. Eng.,

F.R.S. Edin. Ed. 5, 535 pp. N. Y., Paul B. Hoeber, Inc., 1931.

This thoroughly tried and reliable classic has been revised and brought up to date by Dr. Wakeley and may be highly recommended for the purpose for which it is intended—a rapid and authoritative insight into surgical operations for the student. Even the experienced surgeon will find this book worthwhile to have at hand for rapid reference.

**DIE MUND-UND HALSOPERATIONEN.** By Prof. Dr. J. Soerensen. 457 pp. Berlin, Urban & Schwarzenberg, 1930.

Prof. Soerensen of Berlin has produced an unusually well-illustrated book on "Operations of the Mouth and Neck." Forty-eight colored plates render this in actuality a splendid atlas on the subject.

It is to be regretted that in a large octavo of almost 500 text pages there is no index, though the table of contents is quite detailed. The bibliography that we have come to expect in German works is also missing though references are quite frequent throughout the book.

**LEHRBUCH DER MUND UND KIEFERCHIRURGIE.** By Prof. Dr. Erich Sonntag and Prof. Dr. Wolfgang Rosenthal. 444 pp. Leipzig, Georg Thieme, 1930.

This modern text of mouth and jaw surgery is intended for physicians, dentists and students. Concise and up-to-date, it is splendidly illustrated with 501 halftones. The chapter on "Malformation and Deformity" is worthy of special mention as is that on "Tumors," whereas it is to be regretted that only 30 pages are devoted to "Injuries."

**JAHRBUCH FÜR RÖNTGENOLOGEN, 1930.** Under the editorial supervision of O. Rigler-Hufeland. 220 p. Berlin, Walter De Gruyter & Co., 1931.

The year's progress in roentgenology for 1930 is presented in this concise form, written under the editorial supervision of O. Rigler-Hufeland, Brummer, Burgheim, Chantraine, Dyroff, Gröbe, Hedfeld, Hin, Kaestle, Kohlmann, Peltason, St. Rothman, A. Seyerlein, F. Schmitz, J. Schutze, M. Schwarz, W. Stock, O. Strauss, W. Teschendorf, K. Weber, and R. Werner. The authors present in this publication a review of the journal literature in roentgenology, not only summarized but criticized,

this criticism making the summary all the more valuable.

The articles referred to are grouped under: "Physics, Roentgen Ray Biology, Technique, Diagnosis, Therapy, Roentgen Ray Damages and Treatment, Radium Therapy." The reviews are well done and a fair amount of credit is given to American authors, who are usually rather scantily referred to in such German reviews. Indeed, the number of references to American literature is really gratifying as compared with past experiences. Every radiologist who reads German should find in this work a great deal of convenient material for ready reference.

JAMES T. CASE.

**PRACTICAL RADIATION THERAPY.** By Ira I. Kaplan, B.S., M.D. With a special chapter on APPLIED X-RAY PHYSICS, by Carl B. Braestrup, B.Sc., P.E. 354 p., 227 illus. Phila., W. B. Saunders Co., 1931.

There has been a long-felt need for a work in English giving just the information supplied by Dr. Kaplan's book. Several excellent publications on this subject have appeared in foreign languages, and some in English on radium therapy, but nothing in English of a recent nature which deals in practical terms and in such an understandable and generally satisfactory manner with the problems of practical x-ray and radium therapy. In most books of this sort, the preliminary chapters, sometimes amounting to a very considerable portion of the work, deal with apparatus and are accompanied by numerous photographs of equipment of almost every make in order to avoid hurting the feelings of individual apparatus manufacturers. In this book we find the pages devoted to this kind of literature reduced to a minimum. The entire subject of history, definition and action of x-rays and radium and the production of x-rays and radium and radium emanation are all taken care of in 40 pages, leaving the remaining 350 pages for the practical discussion of the clinical aspects. Illustrations are freely employed in a manner to be commended.

All the way through one wonders what were the final results in the cases in which the "before and after" illustrations are presented. It would be interesting to have an additional note on each case as to the remote result. One's feeling about the value of radiation therapy

would be considerably improved if more data as to the outcome were given.

It seems that stress has been laid upon the use of radium rather than x-rays. Combination of both x-rays and radium is recommended in suitable instances. The author evidently accepts the teachings of Regaud, who prefers a very long application of a relatively small amount of radiation in the treatment of most malignancies, when the radiant source is near the lesion.

There are chapters on endothermy, including the description of apparatus and indications; the nursing care of patients suffering from malignant conditions; the plan and scope of a unit radiation therapy plant in a general hospital; and a brief discussion of electrical accidents and radiation burns.

The final page, giving a list of references for collateral reading, indicates the author's recognition of the book's shortcoming; namely, that it is too brief and too elementary in some of its discussions. On the whole, however, this work fills a long-awaited and much needed gap in American radiological literature.

JAMES T. CASE.

**MODERN SURGERY.** By John Chalmers DaCosta, M.D., LL.D., F.A.C.S. Assisted by Benjamin Lipshutz, M.D., F.A.C.S., 1404 pp. Ed. 10, Phila. W. B. Saunders Co., 1931.

The tenth edition of DaCosta's "Modern Surgery" brings up-to-date a favorite work of American surgeons.

Dr. DaCosta points out in his Preface that "In the present edition we have taken the course of revising the different sections ourselves instead of having them looked to by friends and associates." The section by Dr. Chevalier Jackson on "Direct Laryngoscopy, Bronchoscopy, Esophagoscopy and Gastroscopy" still remains. The section on x-ray has been omitted as the author feels that this subject has grown to such a point that it should be treated in a separate volume.

As was to be expected from the pen of this illustrious surgeon, the work presents a splendid picture of the surgery of today. That some things are included and others omitted, which another author would have put in, is to be expected in a work of this character. Dr. DaCosta makes the point in his Preface that the matter of inclusion or omission is entirely up to the author and that the author of a book

of this kind must particularly "try to avoid being caught in the subtle trap of fashion in surgery." This the author has ably avoided and DaCosta's "Modern Surgery," in its tenth edition, may be accepted as a reliable guide to the surgery of today.

**CANCER.** International contributions to the study of cancer in honor of James Ewing. By Frank E. Adair, M.D., F.A.C.S., 480 pages, Phila., J. B. Lippincott Co., 1931.

This book, published in honor of Dr. Ewing's sixty-fourth birthday, consists of as fine a resume of the subject of cancer from all angles as is available today between any book covers. With contributions from the leading specialists in cancer from all parts of the world, it may be considered the outstanding work on the subject today.

Preceding the foreword of the book is an appreciation of Dr. Ewing by William H. Welch which sums up the achievements of Dr. Ewing as only Dr. Welch could do. Dr. Ewing needs no volume to establish his place as the outstanding authority on cancer today, but the fact that he has inspired such a volume may be added to his credit as another achievement of no mean import.

**WILLIAM HENRY WELCH AT EIGHTY.** A memorial record of celebrations around the world in his honor. Edited by Victor O. Freeburg. 230 pp. Milbank Memorial Fund, 1930.

This is one of the most beautifully published volumes of this kind that has yet appeared and is a worthwhile memento of the memorable celebrations of Dr. Welch's birthday.

It is stated that this book is one of a limited edition of 500 copies printed for presentation. It is indeed a book that any collector would be proud to own.

It contains not only the account of the celebrations in Baltimore and Washington but an account of celebrations around the world together with 14 illustrations, most of them reproductions of testimonials to Dr. Welch.

**TEXT-BOOK OF PATHOLOGY.** By Dr. E. T. Bell. 627 pp. Phila., Lea & Febiger, 1930.

This new "Text-Book of Pathology" makes

a particular appeal on account of its brevity. There are 627 pages with over 300 illustrations, covering the entire present-day course of study. Particular mention should be made of the splendid plates accompanying the excellent chapter by Prof. Hal Downey of Minneapolis on "Diseases of the Blood."

**THE TREATMENT OF CHRONIC DEAFNESS BY THE ELECTROPHONOIDE METHOD OF ZUNDBURGUET.** By George C. Cathcart, M.A., M.D. 111 pp. Ed. 2. Humphrey Milford, Oxford Univ. Press, 1931.

The second edition comes to us with the following enthusiastic send-off by the author in his Preface: "I am of opinion from my own experience that until some better form of treatment is invented or discovered no aural specialist can consider himself fully equipped to undertake the treatment of chronic deafness unless he has a Zund-Burguet electrophone." Dr. Cathcart's standing in the otological world is such that his opinion is entitled to more than mere "consideration." The fact that otologists are by no means all of one mind on this subject is indicated by the author's quotations from reviews which criticize other books for recommending this method. The reviewer hesitates to express his own opinion on the subject matter but ventures to say that the book is so well written and presents its case so well that it is entitled to a hearing by otologists so that they may form their own opinion as to the value of the method.

**SURGERY.** By Francis T. Stewart, M.D. and Walter Estell Lee, M.D., Ed. 6, 1307 pp. Phila., P. Blakiston's Son & Co., Inc., 1931.

This sixth edition of the well-known Stewart and Lee's "A Manual of Surgery" has been brought up-to-date by Dr. Lee. The author has had the advantage of having many chapters gone over by specialists so that proper selection and evaluation of the "new" in surgery has been made. The author's hope "that this revision will be found to be conservative, safe and sound" will be found to have been fulfilled.

**BIBLIOTHEQUE DU CANCER. CANCER DU PANCREAS.** By H. Hartman & L. Berard, Directeurs, Dr. A. Chalier Secrétaire. 330 pp. Paris, Gaston Doin & Cie., 1931.

This is the latest volume of the "Bibliothèque Du Cancer" edited by professors Ch. Oberling & M. Guérin. A 330 page monograph on Cancer of the Pancreas will of course be of interest to the specialist. The subject is thoroughly treated and well illustrated. There is a bibliography of over 30 pages. There is also a table of contents but no index.

**PYE'S SURGICAL HANDICRAFT.** BY H. W. Carson, F.R.C.S. Ed. 10, 641 pp. N. Y., William Wood & Co., 1931.

The tenth edition of the revision of Pye's "Surgical Handicraft" was put into the able hands of Dr. W. H. Carson, who died before the completion of the work. However, as indicated in the publisher's preface, he lived to see every page of the MS. leaving only the Preface to be written.

Many of the older surgeons will remember Pye's Manual from their college days. Revised by Carson, the book is today as practical as ever.

**DIE CHIRURGIE DES KROPFES.** By Karl Urban. 85pp., Leipzig, Franz Deuticke, 1931.

In a monograph of 85 pages the author presents his technique on goiter operations, based on over thirty years' experience, and over 4000 cases. A work based on such experience always makes interesting reading, even though American surgeons will not be inclined to agree with all the methods of the author. There are over 40 splendid illustrations in this small volume.

**CANCER AND SCIENTIFIC RESEARCH.** By Barbara Holmes, PH.D. (Cantab.), 158 pp. London, Sheldon Press, 1931.

A short and interesting elementary treatise of 158 pages. It is not intended for the cancer specialist or trained physician. To the beginning student and scientifically inclined layman, the book will furnish an excellent introduction to the subject. It is one of the volumes published in the series "Sheldon Books of Popular Science."

**DIE CHIRURGIE DES VEGATIVEN NERVENSYSTEMS.** By Erich Hesse. Moscow, Staatsverlag, 1930.

This book is published in Moscow and Leningrad by "Staatsverlag," presumably, therefore, by the Soviet Government.



It is unfortunate that the paper used in the text is transparent and, therefore, makes difficult reading. The colored prints, on the other hand, are printed on special paper, as inserts, leaving little to be desired. The binding is poor.

The subject is one of the utmost importance. The Preface is dated August, 1929, so that allowance must be made for the non-inclusion of material published since then. The breadth of the author's reading is evidenced by the large number of American and English citations in the literature. Thirty references to the writings of Adson give evidence of the careful literary research of the author. His own experience extends, according to his own statement, to over 100 operations on the nervous system. No attention is paid to the technique of operation.

The author emphasizes the fact that the subject covered by this book is new ground for the surgeon and that the apparently established ideas of today may be discarded tomorrow. His own claim is that, at the time of publication, his book represents a fair resume of the status of the subject and a rather careful analysis of the contents confirms this claim.

The neuro surgeon will need this book. The surgeon, who only occasionally sees cases of this character, will be glad to refer to it as occasion offers. The book is a very definite indication that our Russian confreres are very much alive to what is going on elsewhere and it is to be hoped that they will publish more books of this character in order to let the world know what they are doing.

This monograph makes no particular contribution to the advancement of science, but, perhaps, presents the best review obtainable of the present status of the subject and this in itself may be considered a distinct contribution.

**DIE KNOCHENBRUCHE UND IHRE BEHANDLUNG.** By Prof. Dr. Hermann Matti. 938 pp. Berlin, Julius Springer, 1931.

In 938 pages with 1000 illustrations, Matti succeeds in presenting the subject of "Fractures and their Treatment" completely and yet without verbosity. Surgeons will find little to criticize in the presentation. As indicated by the extensive bibliography at the end of each chapter, the author knows his literature, and the text indicates a very practical application of this knowledge.

In these days of controversy and discussion of methods and technique of fracture treatment, it is well to have at hand so informative a treatise of the present status of the subject.

**DIE GESAMTE WIEDERHERSTELLUNGSCHIRURGIE.** By Erich Lexer. 1336 pp. Leipzig, J. A. Barth, 1931.

Based largely on experiences in the war, Professor Eric Lexer has revised his surgery into two large well-illustrated volumes, covering the subject thoroughly and completely.

To specialists in this field, the volumes will be indispensable. To every surgeon, reading German, the work will be valuable for reference. The book has over 1900 splendid illustrations and the author has a happy faculty of saying a lot in a few words and of making his subject entertaining as well as scientifically accurate.

**HANDBUCH DER PRAKTISCHEN CHIRURGIE.** By A. Brunner, St. Gallen; W. Felix, Berlin; R. Haecher, Augsburg; A. Herrmannsdorfer, Berlin; R. Nissen, Berlin; F. Sauerbruch, Berlin; G. Schmidt, Munchen. Stuttgart, Ferdinand Enke, 1931.

The second half of Volume II of this splendid set is quite on a par with the previous volumes of the series which were reviewed in the January, 1930 issue of this Journal. It completes what, in the opinion of the reviewer, is the outstanding handbook of practical surgery in any language today.

**LATERAL CURVATURE OF THE SPINE AND ROUND SHOULDERS.** By Robert W. Lovett, M.D., Sc.D. Ed. 5, 240 pp. Phila., P. Blakiston's Son & Co., Inc., 1931.

It is a splendid thing to have Dr. Lovett's classic revised and brought up to date by his former associates. As to the changes in this edition, the editors point out in the Preface that "There has been added Galeazzi's method of treating lateral curvature, a detailed description of the turnbuckle jacket and turnbuckle shell treatment, with reference to the literature and a brief discussion of operative treatment as an adjunct to other methods. The portion of the book devoted to exercises has been practically rewritten, and we wish to express our thanks to Miss W. G. Wright for her assistance in formulating the exercises. Many new illustrations have been added."



With these additions, this book is sure to retain the position it has so long held. It is the best book in the English language on lateral curvature of the spine.

**ROENTGEN INTERPRETATION.** By George W. Holmes, M.D. and Howard E. Ruggles, M.D. Ed. 4, 326 pp. Phila., Lea & Febiger, 1931.

That this book has gone through four editions is in itself proof of its value. The present volume has been brought thoroughly up-to-date. It is intended as an outline of the most modern methods in the interpretation of x-ray films. As the authors say "Such a survey can do little more than cover the essentials of the subject; more detailed textbooks, monographs and literature may be relied upon to supply further data, if required." The authors have succeeded in doing what they set out to do with unusual success. The illustrations have been well selected and well reproduced.

In short this is a book that belongs in the library of every man who is doing any work in x-ray interpretation.

**RADIOLOGISCHE PRAKTIKA. XII and XIII. NORMALE ANATOMIE DES KOPFES IM RÖNTGENBILD (Normal Anatomy of the Head as Seen by the X-ray).** By Karl Goldhammer. Leipzig, Georg Thieme, 1931.

In the two volumes of this beautiful work we find 74 contact prints in the negative, half of them from the dried skeleton, the other half from the living individual, illustrating all the useful positions for the examination of the skull, facial bones, jaws, and the teeth. In each instance there is a copy of the roentgenogram made from the dried skull, with an outline drawing clearly indicating the exact position in which the exposure was made. Following this there is a similar roentgenogram made on the living patient. Each of the roentgenograms is accompanied by a transparent sheet with lines and carefully numbered references to all the important anatomical structures. The references are in four languages, German, English, French, and Spanish, so that the books should have a very wide sale. The roentgenograms are extremely well done, showing a wealth of detail not ordinarily seen and indeed not capable of reproduction except

in the actual photographic prints which make up the books.

Full credit is given to such splendid workers as Holz knecht, Schüller, Mayer, Grashey, and Belot-Lepennetier for their various atlases of the head. The work permits a careful analysis of head roentgenograms, thus allowing its application by experts with long experience and by the less experienced younger colleagues. The dedication reads "To the young physicians as a guide, to the older experienced ones as an advisor."

JAMES T. CASE.

**FUNDAMENTAL PRINCIPLES OF ALVEOLO-DENTAL RADIOLOGY.** By Joseph A. Pollia, M.D. Brooklyn, Dental Items of Interest Publ. Company, Inc. 1931.

One often encounters divergence of opinion between dentists and medical radiologists in the interpretation of alveolodental pathology. In the present work, the author, a physician, seems to have adequately met the requirements of dentists, as is attested by the fact that the book is published by a dental organization. The author very properly calls attention to the fact that there is a difference between a clinically satisfactory roentgenogram and the so-called "gallery" roentgenogram. The first of these is characterized by a softness which is due to the grayness of the general tone. The wealth of detail shown in these films is due to the large scale of gradations of the x-ray absorption thereon recorded. On the other hand, the "gallery" roentgenogram is for exhibition purposes and appeals from the pictorial rather than from the anatomical aspect. Considerable space is devoted to the discussion of the nature and production of x-rays, a fault of most clinical books on radiology. For more than 500 pages the author goes on in encyclopedic detail regarding the technique of dental roentgenography; an analysis of the various pathological processes which increase or diminish radiopacity. The various pathological variations in the index of increased or decreased density and their interpretation consume the rest of the work.

JAMES T. CASE.

**RADIOLOGISCHE PRAKTIKA. Band xv. DIE NORMALE ENTWICKLUNG DES KNOCHENSYSYSTEMS IM RÖNTGENBILD (The Normal Development of the Bones as Seen Roent-**

genically). By Dr. E. Ruckenstein. 63 text illus. 11 curves and 3 tables. Leipzig, Georg Thieme, 1931.

This little work of 78 pages ought to be in the hands of every physician who undertakes to do x-ray interpretation. Really one cannot make satisfactory interpretations of the roentgenograms of the incompletely developed individual without a knowledge of the rate of ossification of the various centers. In addition there are a number of anomalies of development, with which one ought to be familiar.

All this information is here given in condensed, easily accessible form, and well classified for ready reference. The illustrations consist of both diagrams and roentgenograms, and are freely interspersed. Three excellent tables are appended at the end of the book showing graphically the development of the various epiphyseal centers and the rate of ossification from the first month of fetal life to the age of twenty-four years. These are suitable for framing and displaying upon the walls of consulting or class rooms.

JAMES T. CASE.

TECHNICA RADIODIAGNOSTICA (Radiodiagnostic Technic). By Prof. Mario Ponzio. 350 text figs. and 96 half-tone inserts. Unione Tipografico Editrice Torinese, 1930.

In this work of a trifle over 400 pages the author has managed to concentrate a large amount of radiodiagnostic information. After the usual introductory chapters on apparatus, one finds a very satisfactory section on dark room technique. The remaining two-thirds of the book is devoted to technical considerations and interpretations. The number of illustrations is naturally limited by the size of the book. For those who read Italian the book will afford a great deal of up-to-date information. There are discussions on the use of lipiodol in otolaryngological, obstetrical, gynecological, and neurological practice, as well as an adequate chapter on the various methods of opaque visualization of the bronchi, gall bladder, and urinary tract.

JAMES T. CASE.

CINCHONA TERCENTENARY CELEBRATION AND EXHIBITION AT THE WELLCOME HISTORICAL MEDICAL MUSEUM. By Henry S. Wellcome, LL.D., F.S.A., Director, and L. W. G. Malcolm, M.Sc. (Cantab.), F.R.S.E., Conservator. 115 pp., 6 illus., London, The Wellcome Foundation, Ltd., 1930.

Here is another production of the Wellcome Historical Medical Museum with a most interesting list of the exhibits at the Tercentenary Celebration and Exhibition in London.



# PRINCIPLES OF PREOPERATIVE & POSTOPERATIVE TREATMENT

BY

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# PRINCIPLES OF PREOPERATIVE & POSTOPERATIVE TREATMENT

## CHAPTER VII

### DISTURBANCES OF ACID-BASE EQUILIBRIUM: ACIDOSIS AND ALKALOSIS

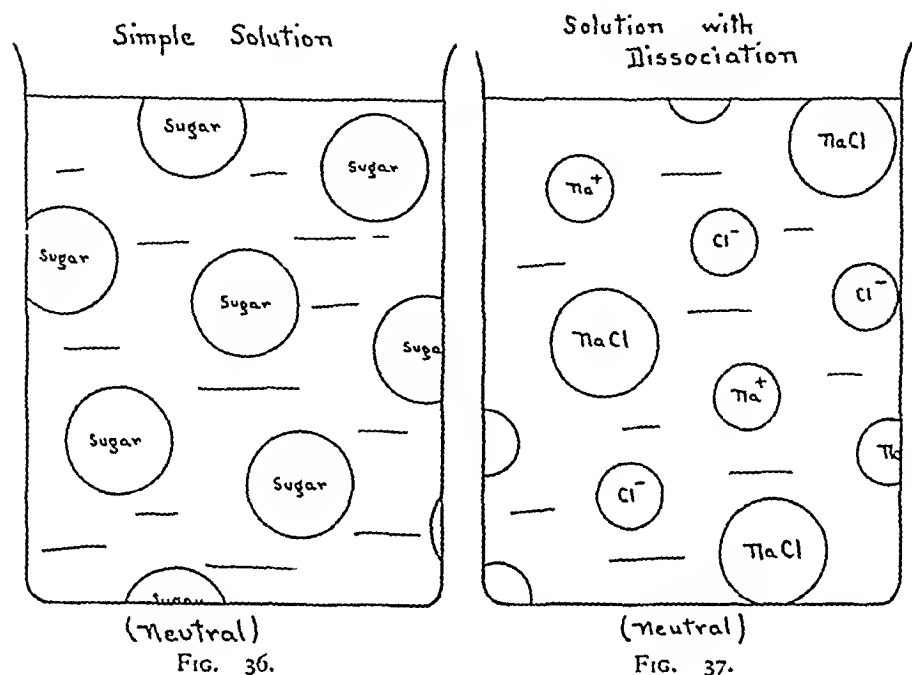
The clinical entities comprehended by the terms "acidosis" and its antithesis, "alkalosis," are conditions which, though frequently discussed and actively treated, are often poorly understood and even less well managed. In order clearly to understand these two conditions, it is first necessary to consider at some length the modern physico-chemical theory of acids and bases.

#### I. SIMPLE SOLUTION, DISSOCIATION, IONS, AND pH

Though the class of substances known as acids is a relatively familiar one, even to the laity, the scientific definition of this class of substances has always been a matter of some difficulty. The older definitions, which simply described certain of the properties of acids, such as the turning of blue litmus paper red, causing a sour taste in the mouth, and reacting with alkalis to form salts, were always recognized as being inadequate in that such descriptions were not really definitive at all; not all of the acids fulfil these requirements, whereas other substances, not acids, frequently do fulfil them. As the result of the efforts of physicists and chemists, working in collaboration, it is now possible to formulate a much more satisfactory definition based primarily upon the behavior of acids and alkalis toward the electric current.

As has been appreciated for many years, acids, alkalis, and most salts when in solution in water possess the property of transmitting the current of electricity; other substances when in solution do not possess this property. The first

class of substances are known as "electrolytes," whereas the second are called "non-electrolytes." The difference between these two classes of substances, according to modern concepts,



is the difference between simple solution and solution with dissociation.

A substance like cane sugar, which goes into simple solution in water, is a non-electrolyte. It dissolves without dissociating, which means that when brought into contact with water it disperses the molecules of which it is composed in such a way that each molecule is equally spaced from every contiguous molecule, the intervening spaces being filled with molecules of water (Fig. 36). The strength of such a solution depends upon the proportion between the number of molecules of the substance dissolved and the number of molecules of the substance in which it is dissolved; a concentrated solution of sugar in water is one in which the sugar molecules are separated by a relatively larger number of water molecules. A

simple solution is a molecular solution, and because molecules possess no electrical properties, such a solution is indifferent to the electrical current.

Substances which not only dissolve but also dissociate, in addition to passing into solution in the previously described manner, proceed one step further in that a certain number of the molecules of the substance dissolved undergo still further cleavage and disintegrate into particles known as ions (Fig. 37). Ions may be simple, consisting of a single element, such as hydrogen or chlorine; or they may be more complex, consisting of two elements, such as a hydroxyl radical ( $\text{OH}$ ); or they may be still more complex, consisting of a number of elements combined, e.g., acid carbonate ( $\text{HCO}_3$ ). These ionic particles are not merely chemical elements or simple combinations of elements, but differ by virtue of the fact that they carry charges of electricity upon them. Certain of these particles or ions possess positive charges of electricity, whereas others possess negative charges.

This property of ions, viz., the carrying of charges of electricity upon them, is expressed graphically by affixing to the chemical symbol of the ion a plus or minus sign according to the nature of the charge of electricity carried. Particles of hydrogen and certain other radicals which break off from molecules to form ions carry positive charges of electricity upon them, and substances which carry charges of positive electricity upon them are known as cations, whereas the radical  $\text{OH}$  and certain other radicals when they break off from a molecule to form ions carry a negative charge of electricity upon them and are known as anions.

To recapitulate, an ionic solution is a solution of a substance which not only disintegrates to form molecules which are equally spaced one from the other, but which also further disintegrates with respect to a certain number of molecules into smaller particles, or ions, which carry upon them electric charges, some of the charges being positive and some of them negative.

The mechanism of the passage of a current through an ionic solution need not be described here, except to state that it involves a migration of ions and a discharge of the electric charges carried upon them.

Neither ions nor molecules are stationary in space. The molecules of a substance in solution are continually in motion, one molecule bombarding against another and being repelled, only to rebound upon still another. Indeed, it is this continual bombardment which keeps the molecules equally spaced. In this sense even a simple solution may be considered as unstable.

An ionic solution, however, is unstable in another sense, in that the molecules of which it is composed are continually disintegrating into ions and subsequently recombining again to form molecules. This reaction takes place in a definite way, so that for a given strength of solution, and for a given substance, there is at any moment a definite proportion between the number of intact molecules and the number of molecules which have become dissociated into ions. It follows that the amount of dissociation of a substance, and, therefore, its ability to conduct electricity is always constant for given amounts of substances in given solution. Pure water, which is a combination of hydrogen with hydroxyl radicals is a very poor conductor of electricity, which is equivalent to saying that only a very small number of its molecules dissociate to form ions.

Without our going into the methods of determining the figures quoted, it has been calculated that a liter of water contains  $1/10,000,000$  of a gram of hydrogen in ionic form. A "normal" solution of hydrogen, by definition, contains 1 gm. of ionized hydrogen to the liter. Consequently distilled water has a normalcy of  $1/10,000,000$ , which fact is expressed mathematically in terms of hydrogen ion concentration, as the normality, or  $N$ , multiplied by 10 to the minus seven power. Because  $N$  multiplied by 10 to the minus 7 power is an unwieldy and inconvenient expression, Sorensen has suggested



the use of a condensed expression which, mathematically, is the *logarithm of the reciprocal of the hydrogen ion concentration*, or in chemical shorthand the pH; pH as here and subsequently described covers only a relatively narrow band of values in the acid-base scale on either side of neutrality; it is inapplicable as a measure of strong acidities or strong basicities, since these represent values beyond the pH scale. Distilled water, according to this terminology, is said to have a pH of 7.

The concentration of hydroxyl ions in distilled water has likewise been determined, and it has been found that the hydroxyl ion concentration is precisely the same as the hydrogen ion concentration (Fig. 38).

This property is a general property of neutral solutions, i.e., in neutral solutions precisely the same number of hydroxyl ions as hydrogen ions occur. In distilled water, therefore, the hydrogen ion concentration, expressed as pH, is 7, and the hydroxyl ion concentration, expressed similarly, is also 7.

The fact has already been stated that in any given solution and at any given moment the number of molecules which have become dissociated as ions bear to the number of molecules not so ionized a constant relationship, and this fact may be expressed mathematically by saying that the concentration of hydrogen ions multiplied by the concentration of hydroxyl ions in any solution is always a constant. This constant is expressed for distilled water by adding the exponents of the figures already given, that is, the concentration of hydrogen ions being "10 to the minus 7 power" ( $10^{-7}$ ), and the concentration of the hydroxyl ions being also "10 to the minus 7 power" ( $10^{-7}$ ), the dissociation constant for distilled water is "10 to the minus 14 power" ( $10^{-14}$ ).

## II. THE RELATION OF HYDROGEN IONS TO ACIDITY

When certain dissociable substances are dissolved in water the relationship of the hydrogen ion concentration to the hydroxyl ion concentration is not as one is to one. Acids in

solution contain a preponderance of hydrogen ions. This can be illustrated concretely by considering what happens when hydrochloric acid is added to distilled water. Distilled water

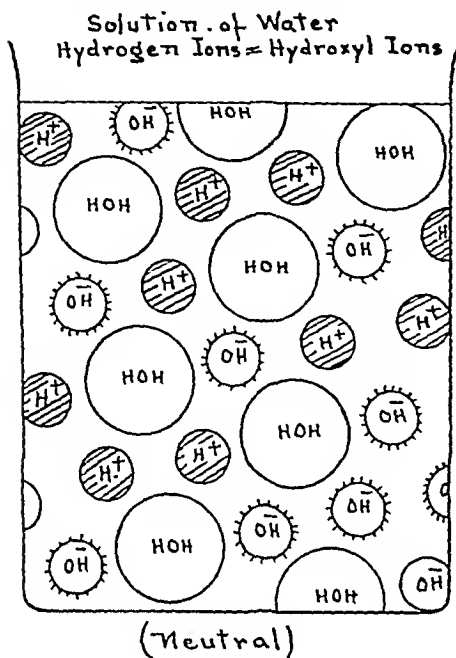


FIG. 38.

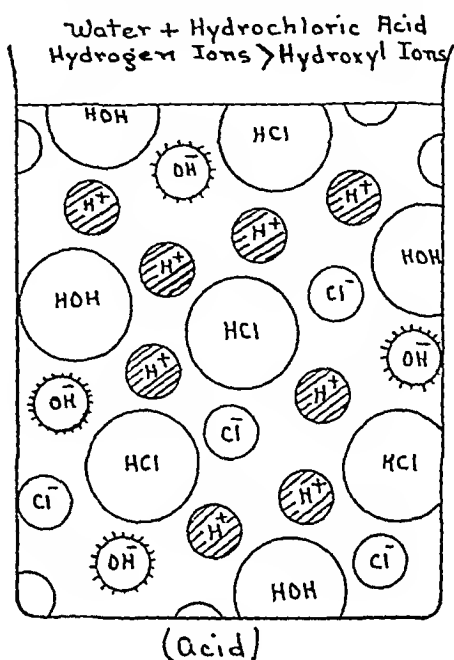


FIG. 39.

is neutral, i.e., it contains in solution the same number of hydrogen ions as hydroxyl ions and, being only slightly dissociated, contains only a small number of hydrogen and hydroxyl ions. Hydrochloric acid, when it goes into solution, dissociates to a relatively much larger extent; it has a high "dissociation constant," only a few hydrochloric acid molecules being found in the solution as such, and a correspondingly larger number of hydrochloric acid molecules being dissociated into hydrogen ions and chlorine ions. In other words, the solution, water, which formerly contained a relatively small number of hydrogen ions and hydroxyl ions, becomes, because of the addition of hydrochloric acid, tremendously augmented by hydrogen ions derived from the dissociation of the hydrochloric acid, whereas, on the other hand, the chlorine ions,

which are liberated from the hydrochloric acid molecules during the dissociation of hydrochloric acid, being chlorine ions and not hydroxyl ions, augment the hydroxyl ion concentration not at all.

Such a solution, which contains a preponderance of hydrogen ions over hydroxyl ions, possesses the property of acidity, and, accordingly, substances which dissociate to form a preponderance of hydrogen ions are known as acids (Fig. 39).

In an acid solution, however, the general law that the product of the number of hydrogen ions and hydroxyl ions is a constant (that is,  $10$  to the minus  $14$  power) still holds good. For this reason, if the hydrogen ion concentration of a solution is known, the hydroxyl ion concentration can be computed by a simple process of mathematics, viz., by subtracting from  $14$  the number used to designate the pH. Furthermore, the pH being expressed in terms not of a number but of the reciprocal of a number, higher concentrations of hydrogen ions are expressed by smaller numbers, viz., a solution having a pH of  $6$  has a greater acidity than a solution having a pH of  $7$ , and likewise a solution having a pH of  $5$  is still more strongly acid than a solution having a pH of  $6$ .

It should be remembered also that since the Sorensen method of expressing pH deals with logarithmic values, a pH value of  $6$  represents just  $10$  times as many hydrogen ions as a pH value of  $7$ , whereas a solution having a pH value of  $5$  contains  $10$  times  $10$ , or  $100$ , times as many hydrogen ions as a solution with a pH of  $7$ .

This constitutes a rather hasty résumé of what happens when acids and bases are allowed to go into solution in water and the theory of hydrogen ion concentration.

### III. BUFFERS AND BUFFER ACTION

Although the addition of an acid to a watery solution always changes the latter in the direction of increased acidity or decreased alkalinity, as the case may be, there are certain solutions of substances to which acids or bases may be added

without changing appreciably the hydrogen ion concentration. Such solutions are known as buffer solutions, and since the fluids of the body are essentially buffer solutions, it becomes necessary to understand the phenomenon of buffering as well as the phenomena of simple solution and dissociation which have already been described.

Buffer action can best be understood by considering a specific example: The acid known as acetic acid,  $\text{CH}_3\text{COOH}$ , ionizes in solution to a relatively small extent; it has a low dissociation constant. The sodium salt of acetic acid, sodium acetate, on the other hand, dissociates to a relatively great extent; it has a high dissociation constant. If, now, these two substances be added to distilled water, such a solution will contain, because of the dissociation characteristics of these substances, a relatively large number of acetic acid molecules and a relatively small number of sodium acetate molecules, together with a certain number of ions representing the disintegration of the rest of the acetic acid molecules and sodium acetate molecules. A relatively small number of hydrogen ions results, because acetic acid dissociates only to a small degree, as already stated. A relatively larger number of sodium ions occurs in solution because sodium acetate dissociates to a relatively high degree. A relatively still larger number of acetate ions results because acetate ions are formed by the disintegration of both acetic acid and sodium acetate.

If hydrochloric acid be added now to such a mixture, hydrochloric acid being an acid which dissociates to a very large extent, there immediately results the addition of a few hydrochloric acid molecules but a correspondingly larger number of hydrogen and chlorine ions. There now exist in solution the following ions: hydrogen, chlorine, sodium, and acetate. It has already been stated that acetic acid dissociates in watery solution to only a limited extent, which, considered in another way, means that hydrogen ions and acetate ions can exist together in the same solution to only a limited extent. Since this is true, the addition of hydrogen ions, as the result

of the addition of hydrochloric acid to the solution, simply results in effecting a readjustment of the constituent parts of the solution whereby the hydrogen ions liberated by the hydrochloric

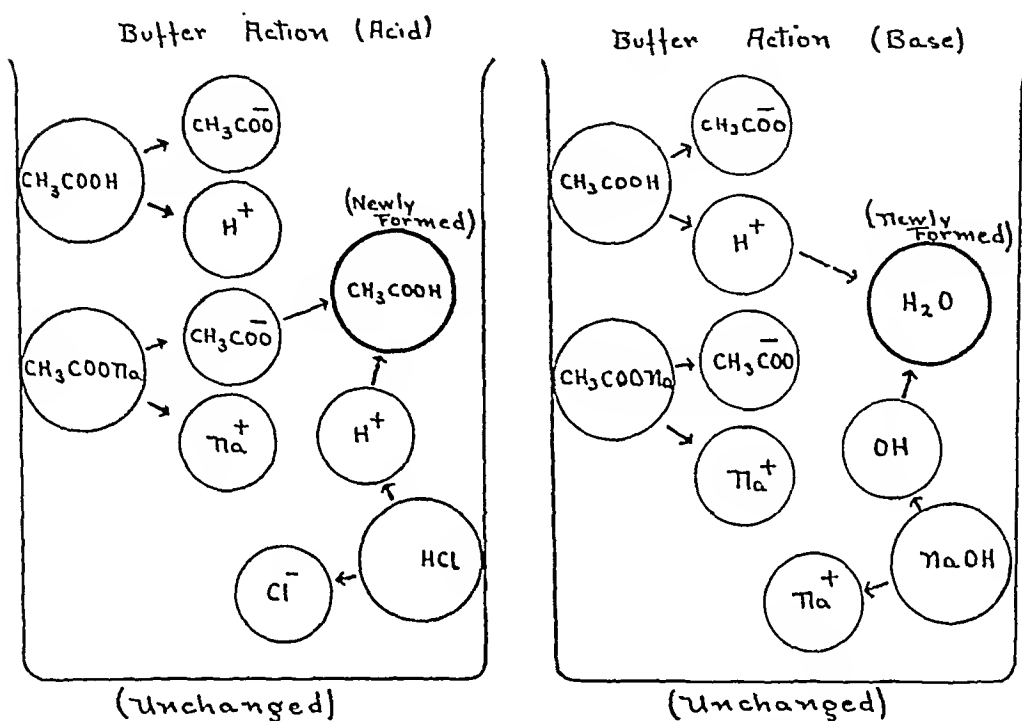


FIG. 40.

FIG. 41.

acid immediately recombine with a corresponding number of acetate ions, derived mostly from the sodium acetate, to re-form acetic acid in the molecular form. Since, furthermore, acetic acid in molecular form in solution has no acidic properties, the hydrogen ion concentration of the solution remains virtually as it was before (Fig. 40).

A similar readjustment without change in pH results when sodium hydroxide is added to a solution of acetic acid and sodium acetate. In this case, as the result of the solution of sodium hydroxide, a large number of hydroxyl ions are immediately liberated. Water, however, is only slightly dissociable, i.e., it is possible for only a few hydrogen and hydroxyl ions to exist together in the same watery solution. Accordingly, the hydroxyl ions derived from the dissociation of the sodium

hydroxide immediately combine with the hydrogen ions already present in the solution to form water. This leaves opportunity for more hydrogen ions to be split off in the solution, and previously undissociated acetic acid, therefore, dissociates to form hydrogen ions and acetic ions, with the net result that the hydrogen ion concentration under these conditions again readjusts itself to the same level as it was before (Fig. 41).

The fact that only a small number of hydrogen ions and of hydroxyl ions can exist in a watery solution at the same time explains why considerable quantities of water may be added to properly buffered solutions without changing the number of hydrogen and hydroxyl ions appreciably, i.e., without changing the pH value. Certain buffered solutions may be diluted with water as much as a thousand times without appreciably changing their pH values.

In general it may be stated that salts of weak acids and weak bases usually exert a buffer action, and since the blood stream and the various tissue fluids contain relatively considerable quantities of such salts, it will be readily appreciated that in the biological sciences buffer action assumes great importance.

#### IV. HUMAN BLOOD CONSIDERED AS A BUFFER SOLUTION

Normal human blood is slightly alkaline in reaction; the pH value may be given as from 7.3 to 7.5, individual bloods varying in health between these narrow limits. The blood serum is approximately 0.2 of a pH higher than that of whole blood, and the pH of the other body fluids probably very closely approximates and follows any changes in the pH value of the blood plasma.

As long as the pH value of the blood and the various tissue fluids is not seriously disturbed life is not in danger by reason of acid-base imbalance. Variations to the acid side are tolerated to a slight degree, a pH of 7.0 for a short time being apparently not inconsistent with life, though figures much below this

invariably are accompanied by dissolution. A pH of 7.0 is considered as the point below which coma occurs. On the alkaline side variations beyond 7.8 are incompatible with life, and as long as life lasts are accompanied by tetany, so that the extreme range of blood reaction compatible with life lies approximately between a pH of 7.0 and a pH of 7.8.

The conditions of acidosis and alkalosis are not always accompanied by an actual change in the pH value of blood. They usually represent, rather, changes in the reserve capacity of the blood to withstand the addition of acids or alkalis without corresponding changes in hydrogen ion concentration, and accordingly represent assaults upon the normal buffer capacity of the blood.

A. COMPENSATED AND UNCOMPENSATED ACIDOSIS AND ALKALOSIS: The principal buffer in the blood is sodium bicarbonate, a salt of the weak acid, carbonic acid. Carbonic acid exists dissolved in the water of the blood stream, and being a weak acid it dissociates but slightly. Sodium bicarbonate, a salt of sodium with carbonic acid, dissociates to a relatively great extent. There are in the blood stream at all times (a) hydrogen and hydroxyl ions derived from the dissociation of water, (b) sodium, and acid-carbonate ions derived from the dissociation of sodium bicarbonate, and (c) hydrogen and carbonate ions derived from the dissociation of carbonic acid. Since acid-carbonate is an acid radical and further dissociates into hydrogen ions and carbonate ions, there is, then, in the blood stream at all times an equilibrium between hydrogen, hydroxyl, sodium, and carbonate ions. If to such a solution some acid be added, for example,  $HX$ , a certain number of hydrogen ions are thereby added to the solution, plus a corresponding number of  $X$  ions.

A readjustment of equilibrium now takes place in accordance with which the hydrogen ions liberated by the acid  $HX$  unite with the hydroxyl ions derived from the dissociation of water to form new molecules of water. Since the product of the concentrations of hydrogen and hydroxyl ions in a

watery solution is always constant and small, a corresponding number of hydrogen ions are immediately released by the dissociation of carbonic acid, with the result that equilibrium is reestablished almost precisely as before, and the pH of the solution remains unchanged.

It must be appreciated, however, that there is a limit to the amount of acid which can be added to a buffered solution without actually changing its pH. The amount of acid which may be added to blood as the result of this buffer action without changing its acidity is known as the "acid reserve" of the blood, and varies with the amount of acid already accommodated.

It should be apparent from these considerations that the addition of acid to a buffered solution, such as blood, which condition may now be given the name "acidosis," may occur up to a certain point without changing the actual pH of such a solution. Such an acidosis is known as a "compensated acidosis." On the other hand, if acids be added to such a solution in excess of the capacity of the buffer action of that solution an actual change in the pH results, and the condition is then known as an "uncompensated acidosis." It should also be remarked that in a solution such as blood which normally has an alkaline reaction, i.e., which has an excess of hydroxyl ions over the number of hydrogen ions, acidosis, whether compensated or uncompensated, represents a relative value, that is, not usually an absolute acidity of the blood, but rather a diminished alkalinity.

Bicarbonates are by no means the only buffer substances upon which the animal body depends for acid-base stability. All the salts of weak acids, contained both within the blood cells and dissolved in the plasma, are capable of performing a similar function. Among the best known of these are the phosphates and the alkali salts of the proteins, which latter behave like weak acids and include reduced hemoglobin and oxyhemoglobin. The primary cleavage products of proteins also apparently exhibit the same property to a minor degree, the



protoses and peptones. The blood is thus supplied with not one, but several, protective buffer mechanisms all of which must be disturbed before actual changes in hydrogen ion concentration can take place to any measurable degree.

The bicarbonates, however, represent the most sensitive buffer properties of all these substances, an action which must be overcome or at least gravely disturbed before inroads are made upon the reserve capacity of the others. This fact has been epitomized by Henderson in his designation of the bicarbonates as the "first line of defense" of the body against acidosis and alkalosis.

B. THE PRACTICAL MEASUREMENT OF ACIDOSIS AND ALKALOSIS, PLASMA  $\text{CO}_2$  COMBINING POWER: Although for certain scientific and experimental purposes it is highly desirable to have some means of determining the hydrogen ion concentration of blood, from a clinical standpoint such determinations are of relatively little value, for by the time either acidosis or alkalosis has advanced to the point of seriously changing the normal hydrogen ion concentration of the blood of a patient that patient is in immediate danger of dissolution, and nothing that can be done for him will be likely to be of much avail. The changes of importance clinically are those which involve the reduction or reinforcement of the buffer action of the blood and which, therefore, represent compensated acidosis or alkalosis, i.e., the early morbid changes in the direction of uncompensated acidosis or alkalosis. Fortunately these changes are capable of determination with a fair degree of accuracy by quantitative chemical methods, and, provided that adequate laboratory facilities be at hand, the clinician need never be in doubt as to the status of the acid-base balance of his patient.

The principle underlying the most practical and usual determination of acid-base balance is the measurement of the so-called "carbon dioxide combining power of the blood." To understand the meaning of this term it is necessary to know that there normally exists in the blood stream sufficient free

carbonic acid to combine with all the alkalis present and not already bound by stronger acids. This means that the excess alkali of the blood exists in the form of bicarbonates. In other words, the alkali radicals of the blood primarily react with the stronger acids to form relatively stable salts, i.e., carbonates, and secondarily with carbonic acid, of which there is always an excess in the blood stream, to form bicarbonates which latter, being salts of a weak acid, are relatively unstable.

The manner in which the bicarbonates act in the presence of the addition of stronger acids to a solution has already been discussed at length as constituting a typical buffer action, and it is evident from this description that the measure of the amount of bicarbonates in such a solution is the measure of the amount of acid which could be added to the solution before the actual reaction of the latter would begin to change.

The most sensitive measure of the milder forms of acidosis and alkalosis might thus well consist, then, in measuring the percentage of bicarbonates in the blood. Chemically this would be a relatively difficult undertaking and from a practical point of view the inaccuracy at best would be considerable. It is, however, much easier to measure the bicarbonate content indirectly by determining the amount of carbon dioxide gas which can be displaced from a unit volume of blood by some acid which possesses the property of splitting  $\text{CO}_2$  from bicarbonates, but not from carbonates, and this is the method which has been found best adapted to clinical needs.

Practically, the method consists, according to the method of Van Slyke,<sup>1</sup> in (a) the withdrawal of a small amount of blood by venepuncture into a tube containing a suitable anticoagulant; (b) the separation of the plasma from the cells of this blood by centrifugalization and the saturation of the resulting plasma with  $\text{CO}_2$  at the normal  $\text{CO}_2$  tension of alveolar air; (c) the addition of lactic acid to a unit quantity of the plasma; (d) the collection and measurement of the volume of  $\text{CO}_2$  gas liberated thereby; and (e) the computation in cubic centimeters of the amount of the gas which would have been liberated had

100 e.e. of blood plasma been used under standard conditions of temperature and atmospheric pressure. Since the volume of gas liberated from 100 e.e. is actually a percentage relationship, volumes of  $\text{CO}_2$  per 100 e.c. of blood plasma, the  $\text{CO}_2$  combining power is expressed in terms of "volumes per cent."

The normal values determined on the basis of many estimations of this variable have been established as from 53 to 77 e.e. of carbon dioxide gas to 100 e.c. of blood plasma. The variable itself is called the "plasma-carbon-dioxide-combining-power." The fact that the chemical process of determining this variable involves the dissociation of the gas rather than the combining of it with some other substance should not mislead one, since combination and dissociation are reversible reactions, and although the practical chemical analysis involves dissociation, the process in the body, the reaction of clinical interest, is the process of combination.

Obviously, from these considerations, the  $\text{CO}_2$  combining power of the blood is reduced when an excess of hydrogen ions is present in the blood stream; these hydrogen ions existing not as free hydrogen ions but combined in stable compounds as carbonate salts, the more carbonate found in this manner the less carbonate there is to combine with carbonic acid in the form of bicarbonate; consequently the less the  $\text{CO}_2$  combining power, and the more severe the acidosis. Conversely the fewer the hydrogen ions in the blood stream, the more the bicarbonate; consequently, the higher the carbon dioxide combining power, and the less the acidosis, or in exaggerated cases the greater is the alkalosis.

Carbon dioxide combining powers in excess of 77 or thereabouts are considered as indicating clinical alkalosis; carbon dioxide combining powers less than 53 are considered as indicating clinical acidosis.

To recapitulate, acidosis and alkalosis represent a condition in which the normal buffer action of the blood is diminished or, in the severe cases, is actually overcome. In moderate acidosis and alkalosis there is merely a reduction in the reserve capacity

of the blood to withstand the further addition of hydrogen ions and hydroxyl ions respectively without at the same time changing the hydrogen ion concentration. In severe acidosis and alkalosis the reserve capacity becomes actually or substantially nil, and the further addition of hydrogen and hydroxyl ions has a direct effect in actually changing the hydrogen ion concentration. Furthermore, whereas the buffer action of blood is dependent upon its content of several salts of weak acids, the buffer salt which bears the brunt of the burden is the salt of carbonic acid, bicarbonate. The entire subject of acidosis and alkalosis is, therefore, closely connected with the chemical reactions of bicarbonates or, since bicarbonates are salts of carbonic acid, with the chemical reactions of carbonic acid, or, again, since carbonic acid represents hydrated carbon dioxide, with carbon dioxide.

C. THE RESPIRATORY REGULATION OF THE CARBONIC-ACID-BASE-BICARBONATE RATIO: All metabolic processes are very closely associated with the production of carbon dioxide, since proteins, carbohydrates, and fats all contain the two constituents of carbon dioxide, carbon and oxygen, and the complete catabolism of proteins, carbohydrates, and fats invariably yields the two elements not as such, but in combination as carbon dioxide gas. Carbon dioxide gas, however, in the presence of water not only goes into physical solution in the water with readiness, but also rather actively combines chemically with it to form the weak acid, carbonic acid.

Carbonic acid, however, being an acid, tends to react with any basic radicals that may be present in a solution to form bicarbonates. The principal base-forming radicals present in blood are sodium and potassium. Consequently, the principal bicarbonates are compounds of sodium and potassium with the bicarbonate ion. The sodium and potassium bicarbonates may be termed collectively the "base bicarbonates."

Since the production of carbonic acid is so fundamental a process in metabolism it is not surprising to find that the body has developed a very special and complex mechanism for

dealing with and ridding itself of this particular acid, for it is obvious that if such were not the case no purely palliative device for maintaining a stable acid-base balance could long remain effective. The principal mechanism evolved to subserve this function constitutes one-half of the cycle known as respiration.

1. *Internal and External Respiration:* The alveolar epithelium of the lungs has long been recognized as the tissue particularly responsible for the elimination of carbon dioxide from the body; this function it subserves in conjunction with a process of absorption of oxygen, both processes together representing the phenomenon known as *external respiration*.

External respiration, however, alone constitutes but a part of the total respiratory process. Fundamentally, respiration is a function of every individual cell of which the body is composed; carbon dioxide must be eliminated and oxygen must be absorbed from each cell in order that the cellular biochemical processes known as life may continue. This cellular exchange of oxygen and carbon dioxide is known as *internal respiration*.

The blood, both cells and plasma, constitutes the medium by which the processes of internal and external respiration are maintained and correlated; it, by virtue of its motility, reduplicates both peripherally in the lungs and centrally at the individual cell a process of oxygen liberation and carbon dioxide absorption. The absorption, transportation, and elimination of carbon dioxide in respiration represents the fundamental biochemical device for the regulation of carbon dioxide, carbonic acid, and the salts of carbonic acid.

Carbon dioxide gas, when liberated from the individual cell by diffusion through the cell membrane, comes first in contact not actually with any of the cells of the blood stream, but with plasma, or, in most cases, with that modification of plasma which is called lymph and which circulates slowly through the various tissue spaces between individual cells.

Carbon dioxide when liberated into a watery medium like the plasma or lymph can assume four physico-chemical

forms: (1) it can exist in simple physical solution as  $\text{CO}_2$ , (2) it can combine with water to form carbonic acid according to the formula  $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ , (3) it can react with dissolved bases to form carbonates according to the formula  $\text{H}_2\text{CO}_3 + 2\text{NaOH} \rightarrow \text{Na}_2\text{CO}_3 + 2\text{H}_2\text{O}$  and (4) as carbonic acid it can react with carbonates to form bicarbonates according to the reaction  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{CO}_3 \rightarrow 2\text{NaHCO}_3$ .

Although a certain rather small percentage of the carbon dioxide formed by the metabolism of the body is capable of being transported by the plasma in simple solution (12 per cent according to Doisy, Briggs, Eaton, and Chambers<sup>2</sup> under the conditions present at the time when arterial blood is changing to venous blood) a greater part is carried by the buffers (25.3 per cent), and a still greater part is carried by the agency of the hemoglobin of the erythrocytes (53.5 per cent).

Simple solution of carbon dioxide in water and reaction with water to form carbonic acid would constitute entirely inadequate mechanisms for purposes of carbon dioxide transportation and would speedily result in local cellular death because of regional acidosis. The buffer action of basic bicarbonates dissolved in the plasma or lymph immediately comes to the rescue in an ionic readjustment which not only avoids any appreciable change in acidity, in accordance with the general principles previously outlined, but which at the same time considerably augments the carrying capacity of the medium for carbon dioxide by virtue of the fact that as soon as a readjustment to any moderate given quantity of carbonic acid has been made the addition of still more carbonic acid simply results in a repetition of the adjustment. This buffer action of *plasma and lymph bicarbonates* is ordinarily amply adequate for purposes of hydrogen ion stabilization and carbon dioxide transportation *locally* and for *relatively small collections of tissue cells*.

A considerable part of the function of the lymph and plasma buffers is, however, merely intermediary; they serve to a considerable extent in the capacity of vehicles to bridge the

gap between the fixed cells of the tissues and the specialized gas transporting cells of the circulation, the erythrocytes. The carbon dioxide carrying capacity of the ultimate carbon dioxide carrier, the circulating blood, is very much augmented by its erythrocyte content. The erythrocyte is as dependent upon buffer action for its capacity to mobilize carbon dioxide as is lymph or plasma, and the principal buffer is the same, base bicarbonate.

Proteins, of which hemoglobin is an example, characteristically behave as weak acids. As is well known, the protein, hemoglobin, is capable of existing in two normal forms, reduced hemoglobin and oxyhemoglobin. These two forms of hemoglobin differ in their respective dissociation constants, which is merely a technical way of expressing the fact that they present different acidity values; oxyhemoglobin is a stronger acid than reduced hemoglobin. Now since erythrocytes contain bicarbonates as well as hemoglobin, the relation between the bicarbonates existing as such and the bicarbonates existing in chemical combination with hemoglobin in the erythrocyte depends upon the chemical state in which the hemoglobin exists, whether reduced or oxygenated. In the oxygenated state hemoglobin chemically binds relatively large quantities of base bicarbonates, but when reduction of hemoglobin occurs base bicarbonates are liberated, due to the fact that the acidity of the hemoglobin is diminished. This reversible reaction accounts for a considerable part of the mechanism of respiration.

When the erythrocytes, coming from the pulmonary circulation, approach the individual cells of which the body is composed, swept on by the impulsion of the heart beat, they contain relatively large amounts of oxyhemoglobin because of their previous circuit through the lungs; a relatively large amount of the base bicarbonates contained within them is, therefore, chemically bound as bicarbonates of oxyhemoglobin. Oxygen, however, being in very loose combination with the hemoglobin begins to diffuse out through the cell membrane as

soon as the partial pressure of this gas in the surrounding plasma becomes low. As soon as reduction of the hemoglobin occurs, however, its acidity is decreased, and base bicarbonate is released. This bicarbonate, furthermore, becomes immediately available for chemical combination with acids and accordingly allows diffusion into the erythrocyte of a quantity of the carbonic acid previously transported by the extracellular plasma.

The exact reverse of this process constitutes the fundamental mechanism involved in external respiration. As soon as the carbon-dioxide-laden erythrocyte is returned to the pulmonary circulation, it finds itself in a medium in which the partial pressure of oxygen on the outside of the cell membrane is greater than the partial pressure within; reduced hemoglobin, having a marked affinity for oxygen, rapidly becomes oxidized, but during this process it becomes much more strongly acid due to the formation of oxyhemoglobin. Its acidic properties immediately express themselves by a chemical reaction with base bicarbonate by which the latter becomes bound. The base bicarbonate, however, no longer existing as such, is unable to take care of its previous quotient of carbon dioxide, which, therefore, immediately diffuses out through the limiting membrane of the erythrocyte and is discharged as gas into the alveolar air and so through the bronchi and trachea into the external atmosphere.

Acidosis and alkalosis are thus seen to depend primarily upon the ratio in the blood between carbonic acid and base bicarbonate and this ratio depends primarily, in turn, upon the process of respiration. The balance in the blood between carbonic acid content and base bicarbonate content is very delicate and is maintained in health at a value of about 1 part carbonic acid to 20 parts of base bicarbonate.

This value is not, of course, an arbitrary one but depends upon a long chain of balanced reactions starting with the partial pressure of carbon dioxide in the alveolar air of the lungs. It determines the ratio between the relative amounts



of carbonic acid and base bicarbonate in the erythrocytes, which in turn determines the ratio between the amounts of carbonic acid and base bicarbonate in the plasma, which finally, in turn, fundamentally determines the acid and alkali reserve capacity of the plasma.

#### V. THE SPECIFIC FACTORS PRODUCING ACIDOSIS AND ALKALOSIS

As has been previously shown, the acid-base balance depends directly upon the carbonic-acid-base-bicarbonate ratio. Since, moreover, both of the factors concerned in this ratio, carbonic acid and base bicarbonate, are capable of undergoing an increase or a decrease with respect to the other to produce a condition of unstable equilibrium, four fundamental derangements of acid-base balance are possible, two of which represent a condition of acidosis, and two a condition of alkalosis. This situation is represented by the following schema:

*Acidosis* results from (1) an increase in carbonic acid or (2) a decrease in base bicarbonate.

*Alkalosis* results from (1) a decrease in carbonic acid or (2) an increase in base bicarbonate.

It remains to consider these four variations somewhat in detail.

A. ACIDOSIS RESULTING FROM EXCESS OF CARBON DIOXIDE (CARBONIC ACID): The acidosis resulting from retention of excess amounts of carbonic acid is essentially a respiratory acidosis, since the formation of carbonic acid and the carbon dioxide content of the blood stand in a reciprocal relation, the one with the other, and the carbon dioxide content of the blood is a direct function of the efficiency of the respiratory mechanism. Since, however, respiration depends not only upon the external respiratory movements and the partial pressure of gases within the respiratory tract but also upon the *circulation*, retention of carbon dioxide within the blood stream may result from either external respiratory or circulatory embarrassment.

Respiratory acidosis may therefore be expected to occur in:

(1) Conditions of venous stasis such as are encountered in cardiac decompensation,

(2) Conditions in which there is a depression of the respiratory center, e.g., in various toxemias and morphine narcosis,

(3) Conditions in which the inspired air contains unduly high percentages of carbon dioxide,

(4) Conditions in which considerable areas of the respiratory epithelium of the lungs become incapacitated, e.g., pulmonary atelectasis, pneumonia, and many other respiratory diseases, and

(5) Conditions in which the hemoglobin content of the erythrocytes is disturbed, e.g., anemia and carbon monoxide poisoning.

Mild degrees of acidosis can rather easily be demonstrated to follow the voluntary holding of the breath. Under these circumstances external respiration largely fails, and because it fails internal respiration is depressed, and carbon dioxide accumulates rapidly. Carbonic acid derived from the accumulating carbon dioxide tends to exhaust the reserve buffer action of the base bicarbonates, and a condition of compensated acidosis tends to develop. The extent to which such a voluntary acidosis can be made to progress is strictly limited, however, because of a stimulatory reflex action on the respiratory center by the carbon dioxide contained in the blood stream; the respiratory center is very sensitive to local changes in acidity, and when disturbed in this manner promptly enforces a compensatory hyperpnea.

Under abnormal conditions, however, a condition of disturbed respiratory function can easily be induced which cannot be overcome by even the most vigorous hyperpnea. In pneumonia, massive collapse of the lung, drowning, impaction of foreign bodies, such as diphtheritic membranes in the trachea, and similar mechanical conditions, no amount of hyperpnea may avail, the interchange of gases previously described as external respiration being physically impossible.

Circulatory embarrassment tends to produce acidosis by interference both with internal and external respiration. The movement of the erythrocytes may be so sluggish that the respiratory mechanism completely breaks down, and compensated acidosis followed by uncompensated acidosis and death speedily ensues.

The treatment of this variety of acidosis should be sufficiently obvious from a consideration of its pathogenesis and need not be elaborated at this point. The fundamental objects of treatment are (1) the restitution of a normal circulation, (2) the supplying of an adequate amount of oxygen to the respiratory epithelium of the lungs, and (3) reinforcement of the hemoglobin content of the blood stream, as by blood transfusion.

Plans of treatment involving an attack upon the acid base balance, as such, would, of course, be relatively futile.

**B. ACIDOSIS RESULTING FROM DECREASES IN BASE BICARBONATES:** A discussion of the variety of acidosis characterized by decreases in the base bicarbonate of the blood stream involves a number of digressions. There are several different ways in which the base bicarbonate may be reduced, the mechanisms of which are sufficiently important to merit separate discussion. A simple schema, like the following, will serve to introduce the fundamental reactions.

Decreases in base bicarbonate result in general either (1) from excessive elimination of base bicarbonate from the body or (2) from replacement of the bicarbonate ion of the base bicarbonate with some other ion to form a new compound. These two factors together with their variations are represented thus:

1. Elimination of base bicarbonate by way of:
  - a. The alimentary tract
  - b. The kidney
2. Replacement of the bicarbonate ion by:
  - a. The lactate ion
  - b. The chlorine ion

e. The acid-phosphate and acid-sulphate ions

d. The diacetate and beta-oxybutyrate ions

1. *Elimination of Base Bicarbonate by Way of the Gastrointestinal Tract:* Considerable quantities of alkaline secretion are poured into the gastrointestinal tract daily (1) by way of the bile ducts from the liver, (2) by way of the pancreatic duct from the pancreas, and (3) directly into the intestinal lumen through the intrinsic secretory action of the intestinal glands. Much of the alkalinity of all of these secretions is dependent upon their base bicarbonate content. Normally this base bicarbonate is not lost to the body but goes through a cycle of secretion and reabsorption; however, under certain abnormal conditions, like severe diarrhea, much of the absorptive power of the intestine may be lost, and the bowel movements may then represent relatively unchanged alkaline intestinal juices. The loss of base bicarbonate under these circumstances may be relatively great.

2. *Elimination of Base Bicarbonate by Way of the Urinary Tract:* A certain amount of base bicarbonate is secreted by the kidney in the urine. The amount ordinarily is not great unless considerable base bicarbonate has been just previously ingested. The kidney, however, assumes an essential part of the function of maintaining the normal base bicarbonate level in the blood stream, and since any normal function is likely to undergo perversion, depletion of the normal base bicarbonate becomes a real or potential danger whenever the secretory action of the kidney becomes deranged in the direction of the establishment of polyuria. Clinically this mechanism is probably of relatively little importance except when it is associated with other complicating mechanisms.

3. *Acidosis Due to Replacement in the Blood Stream of Base Bicarbonate Ions by Other More Reactive Ions:* The mechanism of acidosis which depends upon replacement in the blood stream of base bicarbonate ions with other ions of more reactive properties is one which frequently assumes alarming proportions clinically. So true is this in connection with one group of ions

derived from certain ketone bodies in the disease diabetes that in the minds of some otherwise fairly well informed practitioners of medicine acidosis is invariably interpreted as this particular form of acidosis, i.e., diabetic acidosis or "ketosis." Actually, however, diabetic acidosis represents but one of a number of sub-classes of disturbance of acid base equilibrium characterized by the same fundamental reaction, the replacement of base bicarbonate with acid radicals.

a. Acidosis Due to Excessive Production of Lactate Ions: Lactic acid is produced from the glycogen of muscle tissue during the process of muscular contraction; the normal lactic acid content of resting muscle (about 0.015 per cent) may be increased ten or more times by repeated muscular stimulation.<sup>3</sup>

In the absence of free oxygen this process of lactic acid formation occurs *pari passu* with glycogen decrease, and may be continued by a process of stimulation only up to a certain maximal point since eventually the developing acidity checks further conversion of glycogen to lactic acid. In the presence of free oxygen, however, a certain part of the lactic acid (probably about 20 per cent) is oxidized to carbon dioxide and water, and the energy derived from this reaction is believed to be instrumental in reconverting the remainder of the lactic acid to glycogen during periods of muscular rest.

The concentration of lactic acid in actively contracting muscular tissue is thus seen to be dependent upon two factors (1) the amount of activity, and (2) the presence or absence of oxygen.

Lactic acid, when formed in considerable amounts, as during strenuous exercise, finds its way directly into the blood stream and may increase the normal lactic acid concentration of the blood by as many as ten times. Because of the reactions of the blood previously described it must be evident, however, that free acid cannot exist in the circulation as such; it immediately combines with the most available alkalis to form salts. The most available alkalis are the base bicarbonates, especially sodium bicarbonate, so that within the circulation lactic acid

exists almost solely as sodium lactate. During the process of formation of this sodium lactate, moreover, a certain amount of the available base carbonates is evidently rendered no longer available. Under these circumstances a condition of acidosis ensues, the gravity of which is dependent upon the amount of lactic acid poured into the circulation. There is, of course, in the lungs no mechanism for ridding the body of excesses of sodium lactate; the kidney assumes this function.

Since, moreover, the kidney serves as the organ of excretion for lactic acid the concentration of this substance in the blood is not only dependent upon the amount of its formation in muscular tissue but also upon the excretory efficiency of the kidney. Lactic acid acidosis, therefore, tends to become maximal (1) during strenuous muscular efforts, (2) in the absence of normal oxygenation, i.e., when the respiratory or circulatory function is embarrassed, and (3) when the kidney is damaged. Clinically lactic acid acidosis occurs in its severest forms in connection with convulsions, especially in the presence of the hypoxidation due to failure of the circulation and retention due to kidney damage.

b. Acidosis Due to Excess of Chlorine Ions: The biological reactions and functions of the chlorine ion are not by any means completely understood. It is well known, however, that the concentration of chlorine ions in the blood stream is normally maintained at a relatively constant level regardless of the intake of chlorine-containing compounds by mouth. This regulatory function is subserved chiefly by the kidneys, and when these organs undergo degenerative changes the chlorine ion concentration of the blood tends to increase, unless the chloride intake is at the same time commensurately diminished. The chlorine ion displaces the bicarbonate ion from base forming radicals and therefore is capable of producing a chlorine acidosis.

Chlorine acidosis may result either (1) from excessive chloride administration, whether in the form of hydrochloric acid, sodium chloride, calcium chloride or ammonium chloride,

or (2) from chloride retention, whether the retention be due to actual kidney damage or to the anuria of blood concentration.

c. Acidosis Due to Excess of Acid Phosphate or Acid Sulphate Ions: The kidneys perform an important, though secondary, function in maintaining the acid-base balance of the body. As is well known, the urine becomes acid or alkaline in accordance very largely with the reaction of food material absorbed from the gastrointestinal tract. Though normally more or less acid in reaction, the urine may readily be rendered temporarily basic by the ingestion of alkaline substances and also may be very quickly changed back again by the feeding of acids.

The normal acidity of the urine reflects its primary function in acid-base control, the elimination of non-volatile acids. Within the blood stream the stronger acids react with the buffer salts, mainly the phosphates, and are excreted chiefly as acid phosphates. Weak acids may be excreted as such. Bases are excreted by the kidney not as free alkalis but mainly as disodium phosphate and sodium bicarbonate.

When considerable quantities of strong acids require excretion an interesting protective phenomenon is displayed by the kidney. Were all the acid to be excreted as acid phosphates a serious drain would rather evidently be brought to bear on the concentration of the latter in the blood. The phosphates, being important buffer substance, could not well be spared for the purpose. To meet the emergency the kidney assumes the function of ammonia formation and thereby provides a method of neutralization in accordance with which acids are excreted as ammonium salts, thus sparing the important phosphates for purposes of buffer action.

Kidney damage results in retention of acid phosphates and sulphates; these two radicals react with the bicarbonates and decrease the alkali reserve capacity in the typical manner.

d. Acidosis Due to Excess Diacetate and Beta-Oxybutyrate Ions-Ketosis: "Ketosis" may be defined as a condition in which an excess of ketone bodies occurs in the blood

stream, and a consequent appearance of such bodies occurs in the urine.

The phenomenon of ketosis has been recognized for many years as occurring in connection with a number of diverse conditions: (1) starvation, whether voluntarily induced or secondary to obstructive carcinoma of the stomach, stricture of the esophagus and kindred conditions; (2) after ether and chloroform anesthesia; (3) in connection with parturition, (4) as an accompaniment of various febrile conditions, especially the exanthemata in children, and (5) *par excellence* in diabetes mellitus.

Formerly, the origin of the so-called ketone bodies which appear in the urine in ketosis, beta-hydroxybutyric acid, acetoacetic acid, and acetone (by the presence of which the condition was primarily recognized clinically), and the fundamental metabolic changes underlying the development of the condition were not understood. At present one is in a better position to understand these changes, and although certain features of the disorder are not satisfactorily solved the fundamental aspects of the condition are now fairly well appreciated.

The line of reasoning formerly promulgated to account for the appearance of the acetone or ketone bodies in the urine was that during the process of starvation, in diabetes, or in whatever other connection ketosis might occur, there was an abnormal and compensatory metabolism of the body proteins, a mechanism which was invoked by the organism whenever there was a deficiency of, or an abnormal demand for, sugar; in this process sugar was believed to be formed from protein. At present it is well established that the ketone bodies are produced not in connection with a process of metamorphosis of protein to sugar (a process which is entirely possible, to be sure), but in connection rather with an incomplete combustion of fats. Such incomplete combustion occurs for some reason not well understood whenever there is an inadequate oxidation of sugar, a phenomenon which has been popularly expressed by saying that the fats "burn in the flame of the carbohy-



drates," and the ketone bodies represent the "smoke" which results from imperfect combustion.

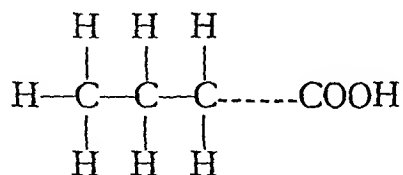
In order to understand the precise manner of production of the ketone bodies one must be familiar with the metabolism of fats. The process of fat metabolism may be reviewed profitably by a consideration of the metabolism of the patient's own stored fats during a period of starvation. It is well known that during starvation the more available sources of energy are invaded first, and that the carbohydrates constitute the first line of defense. The dextrose circulating in the blood stream is first metabolized, and this process rapidly depletes the concentration of sugar in the circulation. A compensatory mechanism is, however, contemporaneously brought into play to maintain the blood sugar concentration by virtue of which additional dextrose is released from the tissues rich in dextrose, especially the muscles and the liver, and coincidentally additional dextrose is released by a process of cleavage from stored glycogen (polymerized dextrose). Ultimately the store of glycogen, however, is so reduced that the metabolism of dextrose is no longer capable of maintaining the normal energy requirements of the organism. Under these circumstances the second most available source of energy is invaded, viz., the fats.

Stored fats occur in the body in the natural fat reservoirs, in the subcutaneous connective tissues, in the retroperitoneal tissues, and certain of the organs such as the liver, in the neutral form, i.e., as esters of the fatty acids with glycerol. Three molecules of fatty acid combine with one molecule of glycerol to form one molecule of neutral fat.

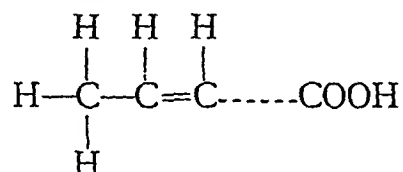
The first process in the catabolism of fat both in vitro, and probably also in vivo, consists in the splitting of the fatty acid radical from the molecule of glycerol. The further catabolism of the glycerol molecule is irrelevant to the production of ketosis and consequently will not be considered.

The oxidation of the fatty acids, however, represents the essential catabolism of the fats, and it is during the process of cleavage of these substances that the ketone bodies are formed.

The fatty acids are relatively simple combinations of carbon, hydrogen, and oxygen, though the molecules at the outset are comparatively large. The molecule consists of a long aliphatic or straight chain, in the case of the saturated series of fatty acids, thus:



In the case of the unsaturated series the structure is the same except for the occurrence of a "double bond" somewhere in the series of carbon atoms, thus:



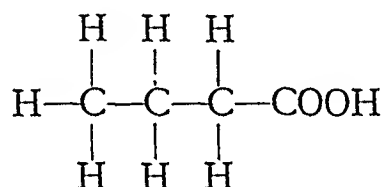
The fatty acids characteristically entering into the metabolism of the human body are mainly three, stearic, palmitic, and oleic, of which the first two are saturated and the last unsaturated.

Obviously, because of the composition of the fatty acid molecule, the end-products of metabolic processes must be carbon dioxide and water, and these are the products evolved when catabolism is complete, i.e., when the complete toll of energy has been abstracted from the fatty acid molecule.

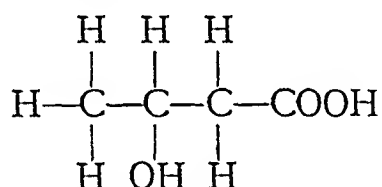
The process by which the intermediate products are formed is unfortunately more or less speculative, due, more than likely, to the transitory character of the reactions involved, according to which the concentration of any given one of the intermediate products at any particular moment is insufficient, normally, to permit of its isolation and identification by chemical means.

All of the usual fatty acid molecules consist of an even number of carbon atoms; palmitic acid consists of 16 carbon atoms, and stearic and oleic acids each have 18.

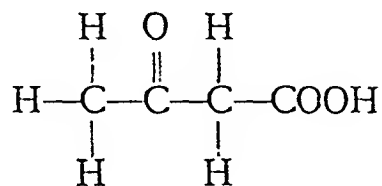
On the basis of certain experimental work with animals Knoop,<sup>4</sup> in 1904, promulgated the hypothesis that oxidation of the fatty acids always occurs at the "beta" carbon atom, and this view is generally accepted. The "beta" carbon atom is the second from the end of the chain, and thus the catabolism is understood to consist essentially of a progressive cleavage of two carbon atoms at a time from the end of the long chain. At all events, in the only condition known in which this process of cleavage is arrested, i.e., in ketosis, the arrest occurs at the four carbon atom stage, a fact which coincides with such a theory. The four carbon fatty acid, butyric acid, has the formula



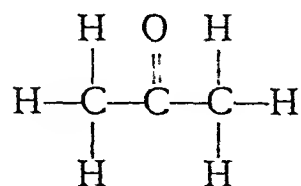
and it undergoes oxidation at the "beta" carbon atom to form beta-hydroxybutyric acid:



On further oxidation beta-oxybutyric acid yields acetoacetic acid,



and acetone,



These substances, with the single exception of acetone, are not regarded as abnormal products of fat metabolism, but on the contrary are considered as forming a part of the normally unbroken series of oxidation products of which the last are carbon dioxide and water.

The essential abnormality in metabolism in the condition of ketosis, therefore, is not the formation of the ketone bodies as such, but rather the failure of these latter substances to undergo still further oxidation to  $\text{CO}_2$  and  $\text{H}_2\text{O}$  according to the normal sequence.

It is interesting to note in this connection that in patients in whom, due to lack of normal secretion from the islands of Langerhans (diabetics), the sugar metabolism is markedly disturbed, and consequently the fatty acid catabolism characteristically shows the arrest under discussion, the feeding of fats containing an odd number of carbon atoms even in large amounts fails to produce a condition of ketosis. The reason appears to be that since cleavage occurs at the beta-carbon atom there never does occur a four carbon atom stage in the catabolism and consequently no formation of ketone bodies.

Van Slyke and Fitz<sup>5</sup> have been able to show that the total amount of acetone bodies (calculated as acetone) circulating in normal blood is 1.3 to 2.6 mg. per 100 c.c. of blood, whereas in the blood of patients exhibiting ketonuria 10-40 mg. (even as much as 350 mg.) are frequently found. Inasmuch as acetone is a very diffusible substance it is rapidly excreted by the kidney, and, accordingly, the concentration of this substance in the urine is much greater than that in the blood at any given time.

As previously stated, it has long been a fact of common clinical knowledge that the appearance of ketosis is associated with disturbances of sugar metabolism. The measurement of this relationship has been made possible, however, only as the result of the fairly recent development of accurate methods of chemical blood analysis. Such methods have revealed that whenever sugar metabolism reaches a certain low ebb, as shown usually by a marked increase in the concentration of the

sugar in the blood, the catabolism of fats develops the characteristic arrest at the four carbon atom stage, and ketosis rapidly ensues.

The most obvious explanation for this phenomenon is that some product of sugar metabolism must be present to unite with the products of fat metabolism before the latter can pass the four carbon atom stage. This substance was supposed by Geelmuyden<sup>6</sup> to be glyeauronic acid, but his hypothesis has been rendered highly improbable by the discovery that other substances beside fats can form ketone bodies and that other substances beside glucose are capable of yielding substances possessing the property of assisting in the complete metabolism of such ketone bodies.

It has been shown that certain of the amino-acids derived from proteins, the "alpha amino-acids," leucine, tryptophan, and phenylalanine, are capable of forming a small quantum of ketone bodies. These acids, when fed to diabetics or added to the blood of experimental animals in perfusion experiments, are found to be capable of producing ketones.

Conversely, glycerol has been found capable of yielding products which assist in the complete oxidation of the fatty acids.

A comprehensive term is, therefore, needed to describe that class of bodies which are capable of uniting with the four carbon atom products of fat and protein metabolism in order that further and complete catabolism may take place, and such substances have been called "antiketogenic bodies"; another term is needed to describe the substances capable of producing ketone bodies, and these have been called "ketogenic substances."

In using this terminology it is evident that at least one molecule of antiketogenic substance must be present for every molecule of ketogenic substance metabolized in order that ketosis may not result. Actually, the relation between ketogenic and antiketogenic substances in the diet and the control of the ketogenic-antiketogenic ratio is a very complex affair

for the reason that the proteins, carbohydrates, and fats of the body are capable of undergoing certain metamorphoses from one to the other and back again, and frequently the practical problems, particularly in the diabetic patient, are most involved.

The variety of acidosis known as ketosis is of especial importance in surgery and for that reason has been considered at some length. Occurring as it does in connection with starvation, pyrexia, ether and chloroform anesthesia, as well as with diabetes mellitus, the surgeon needs particularly to be conversant with its manner of production.

C. ALKALOSIS RESULTING FROM A DECREASE IN CARBONIC ACID: Any condition which is capable of producing hyperpnea is capable of producing alkalosis provided that the factors of circulation and pulmonary architecture remain constant; thus mild degrees of alkalosis may be induced by voluntary hyperventilation. The condition of involuntary hyperpnea, however, produces more marked and permanent alkalosis. Involuntary hyperpnea is most frequently due to stimulation of the respiratory center by pressure, inflammatory processes, pyrexia, or psychic factors such as are found in hysteria.

D. ALKALOSIS RESULTING FROM ACCUMULATION OF ADMINISTERED ALKALI: The relative ease with which the normal acidity of the urine can be reduced or changed to a condition of actual alkalinity by the administration of alkalis by mouth has already been mentioned in another connection. The normal succus entericus of the intestine is alkaline, and relatively enormous amounts of this substance are absorbed daily under physiological conditions. The addition of considerable quantities of alkali to this normal burden is easily tolerated, and under these conditions a corresponding alkali burden is placed on the buffers of the blood stream at least temporarily or until the kidney can arrange to excrete the excess. This function of excretion the kidney is able to perform only slowly so that the temporary net result of massive alkali administrations is the production of alkalosis.

Since, furthermore, the readjustment of the alkali content of the blood stream depends primarily on the kidney, readjustments may be unusually slow in case the kidney is damaged. The development of alkalosis as a result of accumulated alkali thus may represent fundamentally a condition of over-dosage on the one hand or diminished urinary secretion on the other.

Over-dosage of alkali becomes a very real danger whenever alkalis are administered parenterally. Not very many years ago the intravenous injection of sodium bicarbonate was much more widely practiced than at present in connection with the treatment of acidosis. The clinical measurement of degrees of acidosis was at that time a matter of difficulty, and not infrequently unduly large amounts of bicarbonate were unwittingly added to the blood stream, no accurate means of checking the requirements of the case being available. In many instances the end-result of such uncontrolled administration was the mere changing of a condition of alkalosis for one of acidosis, and frequently the recipient of the treatment was actually worse off in the end than in the beginning.

E. ALKALOSIS DUE TO REPLACEMENT OF OTHER IONS BY BICARBONATE IONS: Clinically by far the most important mechanism in the development of alkalosis is the replacement of the chlorine ion by the bicarbonate ion. As previously mentioned, the chlorine ion is more reactive than the bicarbonate ion and displaces it from its base-forming radicals to produce one variety of acidosis; but when, for one reason or another, the body loses its normal chlorine content this reaction becomes reversed, and as chlorine is withdrawn bicarbonate replaces it, with the production of alkalosis. Chlorine is lost to the body most rapidly and characteristically as the result of the persistent loss of hydrochloric acid from the stomach either by vomiting, repeated gastric lavage, or the formation of a gastric fistula. Persistent massive vomiting being particularly prone to occur in connection with obstruction to the upper intestinal tract, as in hypertrophic pyloric stenosis, carcinoma of the pylorus of the stomach, and duodenal ileus,

these conditions characteristically are apt to give rise to an early and acute variety of alkalosis. Postoperative vomiting is more apt to be severe and persistent in connection with operations on the biliary tract than in connection with most other operative procedures, and for this reason postoperative alkalosis tends to occur frequently in connection with biliary surgery.

#### VI. THE CLINICAL RECOGNITION OF ACIDOSIS AND ALKALOSIS

Postoperative acidosis may occasionally be due to any of the factors previously mentioned in connection with the general discussion of the mechanisms concerned in the production of this condition, but certain factors combine to predispose patients postoperatively to the development of that particular variety of acidosis previously designated as ketosis.

In the preceding description of ketosis the rôle of starvation was especially emphasized. Surgical patients, for obvious reasons, characteristically undergo a variable period of starvation, and whenever this period is prolonged the danger of ketosis must be remembered. In estimating the probable hazard from this source the postoperative period of food denial must not alone be considered but also any preoperative restriction of diet which may have been suffered either voluntarily because of food intolerance or involuntarily because of therapeutic restrictions.

Previous to the general recognition of the dangers inherent in starvation, the preoperative preparation of patients frequently involved denial of food for many more hours just prior to operation than is now considered either desirable or safe. In this connection it must be especially remembered that growing children develop starvation acidosis much more readily than adults, and undoubtedly many children have in times past been sacrificed on the altar of too rigorous preoperative preparation.

The especial susceptibility to starvation acidosis of diabetic patients has been mentioned at length in another connection.



It must, however, be remembered that the "potential diabetic," i.e., the patient with a low sugar tolerance, is subject to the same danger as the frankly diabetic patient though, of course, to a less degree. Such a dysfunction as diminished sugar tolerance because of its inherent nature is not likely to be detected by the ordinary preoperative maneuvers in vogue at present, and unless the medical attendant bears the condition specifically in mind in connection with all his patients, he may be occasionally at a loss to explain the condition of the exceptional patient who develops a degree of acidosis apparently unwarranted by circumstances.

In the use of the "Ochsner treatment" for peritonitis and similar therapeutic procedures involving periods of relative or complete starvation, care must be taken that the patient be not saved from his organic disease only to be destroyed by the metabolic upset of acidosis.

General anesthesia also, even apart from attendant starvation, has for some time been appreciated as a source of danger in the production of ketosis. The exact mechanism involved is not thoroughly understood, but, as is well known, most or all of the agents used in the production of general anesthesia, but especially chloroform and ether, are excellent fat solvents. Bloor<sup>7</sup> has shown that this fat solvent action manifests itself in a very definite increase in the fat content of the blood stream during prolonged anesthesia. Presumably, the natural fat reservoirs of the body are partly saturated by the anesthetic agent during anesthesia, and the fat therein contained becoming more liquid and no longer subject to normal restraint, finds its way into the circulation. Fat, thus freed, apparently shows a tendency to undergo much more rapid metabolism than does stored fat, and unless adequate sugar metabolism occurs concomitantly with the fat mobilization, a greater or less degree of acidosis invariably develops.

A somewhat more complicated variety of acidosis is that type which is frequently encountered in the severe diarrheas, especially in the infantile diarrheas. As an illustration of the

manner in which various mechanisms may interact to favor the development of acidosis a slight expansion of the subject of the acidosis of severe diarrhea may be useful. Diarrhea results, of course, from inflammation of the intestinal mucosa, whatever its etiology. In infants diarrhea is apt to be due to some form of intestinal infection, but may be secondary to parenteral infection such as mastoiditis; in adults infection, infestation, or local chemical irritation may be responsible.

As a result of intestinal inflammation exudates are formed, and these add to the normal bulk of the intestinal contents and thus tend to produce undue elimination, but the fundamental pathology is a functional disturbance of the *absorptive* mechanism whereby the intestinal contents tend to be passed on, to, and through the rectum unchanged. The net result of diarrhea is accordingly the immediate loss of large quantities of intestinal secretions rich in bicarbonates.

Although this mechanism of bicarbonate loss undoubtedly accounts for much of the acidosis, many factors contribute secondarily. These latter are associated, for the most part, with the dehydration which almost inevitably ensues when large quantities of fluids are lost to the body, and are directly dependent upon blood concentration.

The immediate effect of blood concentration is, of course, circulatory embarrassment, the viscosity of the blood becomes so great that capillary stasis occurs. Capillary stasis produces the condition of anoxemia which results partly from interference with local internal respiration and partly from interference with external respiration through deficient pulmonary circulation. Thus in diarrhea the primary acidosis of base bicarbonate deficiency is reinforced by the acidosis of carbon dioxide retention.

Incidental to blood concentration and anoxemia still other mechanisms tending to produce increased acidosis are favored. Perhaps the least important of these is increased lactic acid production. Lactic acid is produced during muscular contraction, and although lactic acid is a weak acid the lactate ion is

sufficiently reactive to displace bicarbonate ions from their associated base forming radicals. The excessive muscular efforts of the diaphragm and accessory muscles of respiration incident upon an already established anoxemia tend to form excessive amounts of lactic acid, which in turn tend to neutralize additional base bicarbonate and to establish a vicious circle, decrease of base bicarbonate due to loss by way of the intestinal tract leading to a condition of anoxemia, and anoxemia in turn leading to excessive lactic acid production and further diminution of base bicarbonates.

Furthermore, in a generalized anoxemia such as that under discussion all of the functions of the parenchymatous organs suffer to a greater or less extent. The kidney parenchyma constitutes no exception to the rule and, as previously emphasized, the kidney performs a very important function in maintaining the acid-base balance under normal conditions by eliminating certain acid forming substances in the urine. The particular substances concerned are mainly the acid phosphates and the sulphates. Acid phosphate and sulphate ions, like lactate ions, are capable of displacing bicarbonate ions from their base forming radicals, and thus anoxemia in its action on urinary secretion is seen to favor the establishment of more and more severe grades of associated acidosis.

The treatment of the acidosis of severe diarrhea, as can readily be appreciated from these considerations, is not, therefore, an entirely simple matter. It may be attacked from four different points of view:

1. An attempt may be made to replace base bicarbonate loss by base bicarbonate administration.
2. Blood concentration may be rectified by the copious administration of fluids. Since fluid cannot be absorbed sufficiently well by the gastrointestinal tract it must naturally be introduced parenterally.
3. Diuresis may be favored in an attempt to rid the body of retained acid forming radicals.

4. Rectification of the fundamental pathology may be attempted by seeking to discover and eradicate the factors initially responsible for the diarrhea.

To mention in detail the possible rôle in the production of acidosis of (1) dehydration, (2) of limitation of respiration, as by too tight bandaging and by operative incision, (3) of embarrassment of circulation, as by loss of blood, (4) of kidney damage, and of the host of other contributory factors that may be responsible for postoperative acidosis in general would be but to recapitulate the entire discussion of the subject that has gone before. It should be emphasized, however, that not enough attention has been paid in the past to the very close association between hemorrhage and acidosis. Blood transfusion especially tends to correct acidosis by restoring to the blood stream its normal quatum of carbon dioxide carriers, viz., the erythrocytes, and thus attacks the condition at its source.

The recognition of acidosis clinically in the preoperative or postoperative patient is oftentimes no less difficult than is the understanding of the mechanism by which the condition is produced. Usually acidosis cannot be diagnosed outright, but should be suspected whenever a mental analysis of the case seems to indicate this as the possible cause of symptoms and signs like the following:

1. Drowsiness or mental sluggishness
2. Irritability
3. Hyperpnea
4. Nausea and vomiting
5. Headache
6. Abdominal pain
7. Dehydration
8. Partial suppression of urine
9. Cyanotic or cherry red lips
10. Convulsions
11. Coma

As will be readily understood, none of these symptoms and signs are pathognomonic. They may all at times represent conditions fundamentally quite unrelated to the one under discussion, and to diagnose acidosis on the basis of one or a combination of such symptoms and signs in the absence of laboratory investigations would be hazardous. The determination of the carbon dioxide combining power of the plasma by the method of Van Slyke is a relatively simple laboratory procedure and is one which places at the disposal of the clinician reliable information as to the actual acid-base balance of his patient. Whenever the condition of the patient becomes dubious and a state of acid-base imbalance could account for that condition, no delay should be countenanced in applying the necessary test to solve the dilemma.

The presence of ketone bodies in the urine, though often associated with acidosis, is not necessarily so associated. Ketonuria is occasionally encountered in connection with a normal acid-base balance or even in actual alkalosis.

Postoperative alkalosis has been recognized as a possible surgical complication only within recent years. The occurrence of alkalosis in connection with the vomiting of high intestinal obstruction has been emphasized by a number of investigators, and during the course of the examination of the mechanism by which such alkalosis is produced, evidence has accumulated to show that continuous vomiting, however produced, tends to increase the carbon dioxide combining capacity of the blood. The sequence of events in the establishment of such alkalosis seems to be relatively simple. Gastric secretion tends to be rather strongly acid because of its hydrochloric acid content. Normally this acid is not lost to the body because it is passed on into the duodenum, is neutralized by the alkaline succus entericus of the small intestine, and is subsequently absorbed, not as free acid, to be sure, but as the neutralization products of free acid. In this way no acid forming radicals are permanently lost. If, however, the acid contents of the stomach be expelled by vomiting, the body is thereby deprived of a

considerable amount of free acid. The chlorine ion of the expelled hydrochloric acid is an acid radical, i.e., it is capable of displacing the bicarbonate radical of base bicarbonate, and when this radical is removed the process is reversed, a corresponding amount of base bicarbonate is immediately formed, and the base bicarbonate content of the blood stream is correspondingly increased.

The alkalosis of excessive vomiting tends to be maximal, accordingly, when (1) the amount of vomited material is maximal, and (2) when gastric acidity is high. These two conditions tend perhaps most frequently to be fulfilled postoperatively following operations on the biliary tract and in connection with the development of gastric dilatation. Occasionally ileus develops as a postoperative complication, and in such an event alkalosis may be expected to ensue. The free use of the indwelling stomach tube and the method of continuous duodenal lavage are not without danger, since much gastric juice may be drained away in the use of such methods.

Because during excessive vomiting large quantities of water are characteristically expelled from the body, dehydration tends to occur as an accompaniment of developing alkalosis.

The symptoms and signs of incipient alkalosis are perhaps even more indefinite than those of acidosis; no one symptom or sign is pathognomonic, nor is any combination of symptoms and signs. The condition may be suspected in the presence of:

1. Dehydration.
2. Blood concentration, increase of red cells and hemoglobin.
3. Emesis of large amounts of watery bile-stained material.
4. Low blood-pressure.
5. Marked asthenia.
6. Increase of blood non-protein nitrogen, urea, and creatinine.
7. Presence of urinary albumin and casts.

Clinically, as will now be appreciated, the symptoms of postoperative acidosis and alkalosis are similar; there is usually

a prolongation of the period of immediate reaction from the effect of the operation, vomiting may be persistent, there may be periods of restlessness alternating with periods of languor together with a slight elevation of temperature and flushing of the skin. Headache is possibly more frequent in alkalosis. Acetone bodies may be present in the urine in both conditions. The differentiation depends primarily upon the laboratory determination of the carbon dioxide combining power of the plasma. When this combining power is found to be abnormally low or high, and acidosis or alkalosis can therefore be accurately diagnosed the treatment of the presenting condition, of course, immediately comes into question.

## VII. THE TREATMENT OF ACIDOSIS AND ALKALOSIS

In an attempt to minimize the inherent difficulty of presenting an orderly discussion of the subject of acid-base balance the matter of treatment has already received considerable attention. For this reason the principal object of any specific discussion of treatment at this point is to summarize and unify what has already been said in a fragmentary way.

A. THE TREATMENT OF ACIDOSIS: To state that the treatment of postoperative acidosis is primarily prophylactic is but to repeat an observation which has been applied to so many conditions that it is in danger of becoming hackneyed and unconvincing. In few conditions, however, is the importance of prophylaxis so great as in postoperative acidosis. The four most important factors in the prophylaxis are:

1. Reduction of preoperative starvation to a decided minimum
2. Preservation of water balance and scrupulous prevention of dehydration
3. Parenteral administration of dextrose in quantities sufficient to take care of energy requirements whenever adequate nourishment cannot be tolerated by mouth
4. Massive blood transfusion in cases in which blood loss is considerable.

No considerable expansion of this subject need be attempted at this point, because rather comprehensive references to each of these factors have been made in other connections. However, for the sake of emphasis the functions of both water and dextrose in the prevention of acidosis may be summarized briefly.

*Water:*

1. Tends to prevent the acidosis of blood concentration at its source, since because of its diluent action it makes possible a free capillary circulation in the parenchymatous organs and thus facilitates internal respiration.
2. Acts as the best available diuretic and thereby tends to promote acid excretion by the kidney.
3. Adds bulk to the circulation and thereby tends to prevent the acidosis of circulatory failure; this action is, of course, manifested in maintaining the normal interchange of gases in the pulmonary alveoli, i.e., the maintenance of adequate external respiration.
4. Tends, because of its high specific heat, to regulate the body temperature thus preventing unduly active catabolism of carbohydrates and the consequent production of ketosis.

Talbot, Shaw, and Moriarty<sup>8</sup> have shown that in the case of acidosis developing in children as the result of fasting few subjective symptoms are experienced so long as large amounts of water are ingested and excreted. When fluid intake is diminished the children complain of abdominal pain and become flushed and alternately anxious and languid.

*Dextrose:*

1. Supplies a readily available source of energy while at the same time sparing fat catabolism, and also preventing the production of ketosis by supplying antiketogenic bodies to neutralize the ketogenic bodies derived from unavoidable fat catabolism.
2. Acts as a diuretic second only in efficiency to water itself and thereby tends to prevent the retention of acid-waste products.

In the severest types of acidosis a direct attack may be launched on the carbonic-acid-base-bicarbonate ratio by the intravenous injection of sodium bicarbonate. When attempting such therapy it must be remembered, however, that a merely temporary expedient is being adopted and that the utmost



that can be expected is a temporary readjustment of values, such that the patient does not immediately die of increased hydrogen ion concentration. Bicarbonate therapy establishes no direct contact with the fundamental pathology, which, of course, represents excess formation of acid radicals, and unless this excess formation of acid radicals can be adequately prevented, the condition of the patient is permanently improved not at all.

#### SODIUM BICARBONATE SOLUTION FOR INTRAVENOUS INJECTION

A suitable solution of sodium bicarbonate for intravenous injection may be made by weighing out on a piece of sterile paper 5 gms. of sodium bicarbonate, removing the bicarbonate from the middle of a clean package of reliable manufacture. The transfer of the material to the sterile paper should be by means of a metal spatula previously sterilized by flaming. The sodium bicarbonate is then dissolved in 100 c.c. of sterile freshly distilled water. Such a solution is neither isotonic nor absolutely sterile, but may be given intravenously with relatively little danger.

In infants and children, however, in whom the subcutaneous or intraperitoneal administration of the drug is deemed advisable, such a solution is unsuitable because of its lack of sterility and because also of its lack of isotonicity. Inasmuch, furthermore, as solutions of sodium bicarbonate can not be sterilized by heating because they decompose into the irritating substance sodium carbonate, sterilization of such solution can be accomplished only by means of filtration through a Berkefeld filter. To make a suitable solution, therefore, for either subcutaneous or intraperitoneal injection, it is necessary to adopt the following procedure: Dissolve 1.5 gms. of sodium bicarbonate in freshly distilled water. Add sufficient phenol red to the solution to produce a distinct coloration. Pass solution thus made through a Berkefeld filter and just prior to use allow carbon dioxide gas to bubble through the solution under sterile conditions until the color of the solution changes

from red to orange. A dose of sodium bicarbonate which is usually safe consists of 0.5 gms. of sodium bicarbonate per kilo of body weight. It is roughly equivalent to one-fourth of the sodium bicarbonate normally found in the body fluids of a patient.

*The Administration of Sodium Bicarbonate and the Development of Tetany:* The danger of the development of tetany in connection with the administration of sodium bicarbonate has been appreciated for a number of years. Numerous cases of tetany developing in children under such therapy have been reported<sup>9</sup> and alkali tetany in adults is by no means unknown.<sup>10</sup> The mechanism involved in the development of this complication is open to question.

According to Van Slyke<sup>11</sup> and his followers tetany may be expected to develop whenever the pH of the plasma reaches a value of about 7.8, regardless of the manner in which this change is effected. On the other hand, Greenwald<sup>12</sup> and his followers contend that alkalosis as such plays an unimportant part in the development of sodium bicarbonate tetany, and that the tetany of this form of alkalosis represents essentially a condition of sodium poisoning. According to the latter conception the appearance of tetany is an indication of the poisonous effect of the sodium ion.

Denis and von Meysenbug<sup>13</sup> have presented evidence to substantiate Van Slyke's hypothesis with respect to the action of sodium bicarbonate as such, but have also apparently demonstrated that the sodium ion itself is capable of producing a generally similar condition of spasmophilia in the absence of increases of pH or  $\text{CO}_2$  content. Such spasmophilia was found to occur following the injection of large amounts of sodium chloride or sodium sulphate.

**B. TREATMENT OF ALKALOSIS:** Since varying degrees of dehydration characteristically accompany the development of alkalosis, the administration of quantities of water is invariably indicated. The stomach and upper intestinal tract being intolerant to nourishment of all kinds, parenteral administration

of fluids becomes necessary. A metabolic upset like the one under discussion is invariably a matter of grave concern, so that temporization with relatively uncertain methods of fluid administration cannot be trusted. Intravenous infusion is usually the method of choice.

Since, furthermore, alkalosis usually depends partly upon a chlorine ion deficit an attempt should be coincidentally made to supply an excess of chlorine ions. In connection with the use of intravenous infusion this may conveniently be attempted by using a hypertonic solution of sodium chloride as the infusion vehicle. Sodium chloride solutions of a strength between 2 and 5 per cent are suitable, but in view on the one hand of the large amounts of fluid required, and on the other, of the danger of pushing the administration of markedly hypertonic solutions too vigorously less concentrated solutions, 1 per cent or 2 per cent and in larger amounts are much to be preferred.

When alkalosis is dangerously high an attempt may be made to supply chlorine ions in a still more available form; ammonium chloride when given by rectum is a very satisfactory substance, as it is absorbed relatively rapidly. Calcium chloride can be used intravenously and serves as an easily available source of chlorine ions.

The intravenous injection of sodium acid phosphate may be used as a last resort. This substance is an acid salt normally found in the blood stream and excreted by the kidney. The rationale of its use in alkalosis depends upon its acid properties, and the use of this substance makes a direct attack on the acid-base balance of the blood much in the same manner as does the use of sodium bicarbonate in the treatment of acidosis. The administration of this substance also, like the administration of sodium bicarbonate, is not without danger, because it is impossible to tell by observation of symptoms and signs the extent of the acid-base readjustment. The danger of exchanging an acidosis for an alkalosis is great, unless repeated  $\text{CO}_2$  determinations are made at frequent intervals. Further-

more, the exhibition of this substance may be expected at best to give only symptomatic relief, since neither the dehydration nor the hypochloremia which usually underlies the condition is alleviated in the slightest. The elimination of this substance by the kidney is relatively rapid under normal conditions of renal activity, and consequently the effect of sodium acid phosphate therapy may be expected to be somewhat transitory.

#### HARTMANN'S "COMBINED SOLUTION" OF "BUFFER SALTS"

From the point of view of the therapy of acidosis and alkalosis, an ideal situation would be one in which there could be administered a single solution of such composition as to correct a condition of acidosis on the one hand or a condition of alkalosis on the other. From the discussion that has preceded it will be readily seen that such a solution must needs be capable of performing the four following functions: (1) It must contain a sufficient amount of water to combat the dehydration which is almost invariably present in both acidosis and alkalosis. (2) It must contain sufficient chloride, preferably in the form of sodium chloride, to counteract the chloride deficiency which is characteristic of cases of alkalosis. (3) It must be capable of releasing sufficient base-bicarbonate to neutralize any excess concentration of hydrogen ions which may be present in acidosis, and (4) it must contain some chemical mechanism which will prevent intoxication by the sodium ion of the sodium chloride such as might occur in cases of acidosis in which no excess of sodium ion is required. Such a solution has actually been devised by Hartmann for use clinically. Theoretically the solution seems to fulfil adequately all of the above named requirements, and although the exact clinical evaluation of this solution has not yet been subjected to the acid test of sufficiently wide usage at the present writing, either the solution in its present form or the solution as it may subsequently be modified seems to promise much for the future.

The solution is made as follows: Into a 1-liter volumetric flask measure 60 c.c. of C. P. lactic acid, add enough dry phenol red indicator to color the solution perceptibly. Neutralize the solution with a saturated solution of sodium hydroxide from which the carbonate has been previously removed by sedimentation. Add 150 gms. of sodium chloride, 10 gms. of calcium chloride, and 5 gms. of calcium chloride crystals (i.e., calcium chloride which contains two molecules of water of crystallization). Add sufficient freshly distilled water to make exactly 1 liter. Transfer the solution without losing any of it to a clean beaker and boil the solution for thirty minutes in order to hydrolyze the lactic acid anhydride resulting from the chemical action which takes place when the preceding reagents are brought together. During this process of boiling neutralize the solution with strong sodium hydroxide as frequently as the color of the solution indicates that it is becoming acid. At the end of thirty minutes cool the solution to room temperature, replace it in the volumetric flask, and restore the original volume with distilled water. Filter the solution through fine mesh filter paper. Divide it into convenient amounts, place it in suitable receptacles and autoclave it at 15 lbs. pressure for thirty minutes. Each 10 c.c. portion of the solution contains 85 per cent lactic acid (as sodium lactate) 0.6 c.c., sodium chloride 1.5 gms., potassium chloride 0.1 gm., calcium chloride 0.05 gm. The hydrogen ion concentration ranges between 7.3 and 8.7. *The solution is diluted with 25 times its volume of sterile freshly distilled water before injection.*

It is usually injected intravenously in adults but may be administered subcutaneously or intraperitoneally in infants and young children or in other patients in whom intravenous administration is for one or another reason undesirable or contraindicated. Instead of distilled water sterile dextrose solution of any proper percentage may be used as a diluent. The dextrose solution may be preferable especially in those cases in which it is desirable to provide the patient with readily available food energy, in those cases in which there

has been damage to the liver, or in those cases in which the diuretic action of the dextrose is desired.

Because of the relatively large amount of water this solution contains it has a tendency to restore diminished blood volume and to promote diuresis. The chloride ion is supplied in relatively large amounts as sodium chloride. Thus an excess of chloride ions is available if needed. The solution contains potassium and calcium ions, however, in sufficient amounts to balance the excess of chloride ions in those cases in which the latter are not needed. Because of the sodium lactate present in the solution, it is a potential alkalinizer, that is the solution of sodium lactate gradually decomposes to form sodium bicarbonate. This reaction, however, does not occur at a rate so rapid that it exceeds the excretory ability of the kidney and therefore does not accumulate in extensive amounts in the blood stream, being either excreted as formed on the one hand, or being utilized for the correction of acidosis on the other.

#### VIII. RÉSUMÉ

According to modern physical chemistry acids may be defined as substances which dissociate in watery solution in such a way as to form hydrogen ions, and bases as substances which dissociate to form hydroxyl ions. The measure of the acidity of a substance is its ability in solution to produce a greater or lesser number of hydrogen ions, whereas similarly the measure of its basicity is its ability to produce hydroxyl ions. Since, however, water itself is capable of dissociating into both hydrogen and hydroxide ions and does so dissociate, there is in every watery solution a mixture of both hydrogen and hydroxyl ions regardless of whether or not there exist dissolved in it other substances which dissociate to form such ions. The fact that distilled, or pure, water is neutral in reaction does not mean that neither hydrogen nor hydroxyl ions are present but rather that precisely as many hydrogen ions are present as hydroxyl ions.

When acids are added there results simply an increase of the hydrogen ions over the hydroxyl ions, there still being a certain number of hydroxyl ions due to the dissociation of water itself; similarly when bases are added the hydroxyl ions outnumber the hydrogen ions, though a certain number of the latter are still present, due again to the dissociation of water.

The addition of an acid or a base to a watery solution does not, however, simply add a certain number of hydrogen or hydroxyl ions to the solution, as the case may be, but brings about a reciprocal change in the hydrogen-hydroxyl ion ratio, i.e., the addition of hydrogen ions *ipso facto* decreases the number of hydroxyl ions previously present, and vice versa. This phenomenon accounts for the fact that whereas the addition of an acid to a watery solution always changes the latter in the direction of increased acidity or decreased alkalinity, as the case may be, the preexisting composition of the solution as well as the amount and strength of the added acid or base determine the exact amount of the change.

The composition of human blood is such, due to the presence in it of various salts and proteins in solution, that the addition of comparatively large quantities of hydrogen ions as acids or of hydroxyl ions as bases change its hydrogen ion or hydroxyl ion concentration but little or not at all, i.e., due to reciprocal changes between the added acid or alkali and the substances already present in solution, the net difference between the hydrogen and hydroxyl ions present afterward is not different from its previous value.

The addition of acid or basic radicals does, however, affect the buffer substances, and the net result is a diminution in the ability of the buffer substances to withstand the further addition of more of the acid or basic radicals even though the actual hydrogen ion concentration of the blood may not be affected in the least. Assaults upon the normal buffer mechanism, the hydrogen ion concentration itself being unaffected, constitute "compensated" acidosis or alkalosis. On the other hand, when the normal buffer mechanism breaks down and

actual changes in hydrogen ion concentration occur the condition is known as a "decompensated" acidosis or alkalosis.

A. Neither acidosis nor alkalosis can be diagnosed merely on the basis of clinical manifestations.

(1) Common clinical findings in acidosis include:

- a. Irritability or drowsiness and mental sluggishness
- b. Nausea and vomiting
- c. Dehydration, blood concentration
- d. Cyanosis or "cherry red" lips
- e. Partial suppression of urine
- f. Headache
- g. Convulsions and coma

(2) Common clinical findings in alkalosis include:

- a. Asthenia
- b. Vomiting of watery, bile-stained material
- c. Dehydration, blood concentration
- d. Low blood pressure
- e. Urinary albumin and casts
- f. Headache
- g. Tetany and coma

Disturbances in acid-base balance should be considered in all postoperative cases in which convalescence is unsatisfactory and findings like those mentioned, when present, cannot be adequately explained on some more obvious basis.

B. The most useful short method of determining the acid-base balance is Van Slyke's blood-gas determination, the "carbon-dioxide-combining-power of the plasma."

(1) It is a value obtained by measuring the amount of carbon dioxide liberated by the complete disintegration of the base bicarbonates.

(2) It is, therefore, simply an indirect way of measuring the concentration of the base bicarbonates themselves, a procedure which would be technically too difficult and too unreliable for routine use.

(3) The normal variation of the plasma  $\text{CO}_2$  combining power is considerable, 53 to 77 volumes per cent. (By "volumes



per cent" is meant simply "volumes of  $\text{CO}_2$  per 100 c.c. of plasma.")

(4) Values greater than 77 may be taken as indicating alkalosis, a greater-than-normal amount of base bicarbonate; values less than 53 may be taken as indicating acidosis, a less-than-normal concentration of base bicarbonate.

C. "In vivo" the ratio between the base bicarbonates ( $\text{BHCO}_3$ ) and the carbonic acid ( $\text{H}_2\text{CO}_3$ ) of the blood stream is the fundamental relation governing acid base balance,

$$\frac{\text{BHCO}_3}{\text{H}_2\text{CO}_3}$$

(This is but another way of saying that the base bicarbonates constitute the first line of buffer defense.)

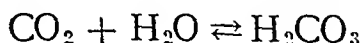
(1) The addition of moderate amounts of acids to the blood stream changes the ratio in the direction of diminution of the base bicarbonates, but if compensatory elimination of carbonic acid occurs the ratio may immediately readjust itself (compensated acidosis).

(2) The addition of moderate amounts of bases to the blood stream changes the ratio in the direction of increase of the base bicarbonates, but, again, if compensatory retention of carbonic acid occurs the ratio may immediately readjust itself (compensated alkalosis).

(3) It should be sufficiently evident, however, that in spite of this compensation the amount of base bicarbonate undergoes in either case an absolute change, the measure of which is the "carbon dioxide combining power."

(4) Only when the ratio fails to readjust itself does an actual change in the hydrogen ion concentration of the blood occur (uncompensated acidosis or alkalosis).

D. The fundamental regulating mechanism of the carbonic acid in the blood is respiration: carbon dioxide in the blood is in equilibrium with carbonic acid in accordance with the simple formula:



It follows:

(1) That the integrity of the respiratory system must be maintained if changes in acid-base balance are to be prevented.

(2) That inasmuch as the integrity of the respiratory system is directly dependent upon integrity of the circulatory system, failure of the circulatory system affects the acid-base balance almost as directly as failure of the respiratory system itself.

(3) That inasmuch as the integrity of the circulatory system depends not only upon a sufficient volume of circulating fluid but more especially upon a sufficient number of circulating erythrocytes, blood transfusion often serves as an admirable means of combating acidosis almost at its source.

*E.* A secondary regulating mechanism of acid-base balance is the kidney. This organ when functioning properly:

(1) Excretes bases (particularly in the form of base bicarbonates) or

(2) Excretes acids (particularly in the form of acid phosphates),

when these substances are present in the blood stream in excessive amounts.

Practically and therapeutically it should be remembered

(1) that water is the most efficient diuretic and

(2) that, next to water, dextrose solution is the most efficient diuretic.

*F.* The fundamental chemical reactions responsible for the development of clinical acidosis and alkalosis may be tabulated as follows:

Acidosis results from:

(1) Increase in carbonic acid due to

a. respiratory embarrassment

b. circulatory embarrassment

(2) Decrease in base bicarbonates due to

a. excessive elimination by the

—alimentary tract

—kidney

- b. replacement of the bicarbonate ion with some more reactive ion
  - lactate ion
  - chlorine ion
  - acid phosphate and sulphate ions
  - diacetate and beta-oxybutyrate ions

Alkalosis results from:

- (1) Decrease in carbonic acid (hyperventilation) due to
  - a. voluntary hyperpnea
  - b. involuntary hyperpnea
- (2) Accumulation of administered alkali due to
  - a. faulty elimination
  - b. overdosage
- (3) Replacement of other ions by the bicarbonate ion, especially the
  - a. chlorine ion
  - b. lactate ion

G. Attempts at readjustment of perverted acid-base balance by the addition of acids or bases directly to the blood stream are intrinsically irrational:

(1) Such methods are dangerous because unless controlled with the utmost care they may merely substitute an acidosis for an alkalosis, or vice versa.

2. They serve merely as temporary expedients because the added substances tend to be speedily removed from the circulation (mainly by diuresis).

(3) The acids or bases commonly used for the purpose may effect a readjustment of acid-base balance, but do not correct the fundamental abnormality.

The common substances used are sodium bicarbonate (in the treatment of acidosis), and sodium acid phosphate (in the treatment of alkalosis).

(1) Even though  $\text{CO}_2$  determinations show the plasma bicarbonates to be at a low level the administration of sodium bicarbonate does not necessarily correct the abnormality, because not the plasma bicarbonates, but the red blood cell

bicarbonates are mainly concerned in the transportation and elimination of  $\text{CO}_2$ .

(2) In ketosis there is no fundamental deficiency of bicarbonates, but rather an excess of foreign acids; prevention of the formation of these acids can readily be accomplished.

(3) Sodium acid phosphate injections in alkalosis supply no chlorine ions to the circulation and therefore do not attack the abnormality fundamentally at all.

*H.* Unless some abnormality of pancreatic secretion exists (diabetes or possibly pancreatitis) the use of insulin to "buffer" dextrose solution for intravenous injection is irrational and sometimes distinctly dangerous.

(1) Insulin and dextrose do not react like two chemical compounds to form a new compound.

(2) One unit of insulin ensures the metabolism of 1 gm. of dextrose only in the completely depancreatized animal.

(3) The possible functions of insulin are:

a. It facilitates glycogen storage in the liver.

b. It possibly converts dextrose into some more oxidizable hexose.

c. It produces blood concentration by increasing the affinity of the tissues for water.

The rational treatment of acidosis and alkalosis depends upon an adequate understanding of the physico-chemical mechanisms responsible for acid-base imbalance. The problem is fundamentally one of prophylaxis. The active treatment in the already developed condition of acid-base instability should be directed against the cause.

The indications for accessory therapy are most commonly met by the administration of one or a combination of the following:

In acidosis:

1. Blood transfusion.

2. Intravenous infusion of glucose solution (without or without insulin).

3. Intravenous infusions of "artificial serum" solutions.

4. Intravenous infusion of sodium bicarbonate solutions (only rarely and in desperate cases).

In alkalosis:

1. Intravenous infusion of artificial serum solutions.
2. Intravenous infusion of sodium or calcium chloride solutions (either isotonic or slightly hypertonic).
3. Enteric administration of chlorides (especially ammonium chloride by rectum).
4. Intravenous infusion of acid sodium phosphate solutions of about 2 per cent strength (only rarely and in desperate cases).

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## PARATHYROIDISM\*

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THE most interesting recent surgical publications in the endocrinological field have been the observations on tumors of the pancreas, or better, of the islands of Langerhans, causing hyperinsulism, certain tumors of the suprarenals causing paroxysmal high blood pressure and tumors of the parathyroids responsible for various osteomalacic processes. All three conditions caused by tumors or states of hyperfunction of these tissues are curable by removal of the tumors, or the over-active endocrine organs involved.

This paper will discuss a group of cases of hyperparathyroidism. Just as exophthalmic goiter is considered to be due to an exaggerated thyroid function, and myxedema to hypothyroidism or lessened function of the gland, so we have learned that the parathyroids are, in a like manner, responsible for two clinical conditions. If the parathyroids are injured, as sometimes happens in the course of a goiter operation, a complex of symptoms follows which is known as tetany. If the parathyroid action is stimulated by tumor formations or other pathological processes in the gland, a complex of symptoms follows now called hyperparathyroidism. It is characterized mainly by interference with the calcium content of bones. Myxedema and tetany are both treated successfully by extracts of the respective glands. The hyperactive states of both glands seem to be treated best by surgical removal of tumors of the two glands, or by partial

excision of the gland tissue. The comparison between these two organs can be carried on indefinitely. Over-feeding with thyroid extract will cause an abortive picture of an exophthalmic goiter. Giving large doses of Collip's parathormone will cause a mild degree of osteomalacia comparable to that seen in parathyroidism.

In exophthalmic goiter, as now in parathyroidism, surgeons were at first afraid to remove too much of the gland, fearing postoperative myxedema, or postoperative tetany, respectively. Now we learn that such postoperative deficiency symptoms can be prevented by the use of thyroid or Lugol's solution in the case of the thyroid and the same can be accomplished by parathormone after parathyroidectomy. This comparative endocrinology is a most interesting study.

Quite definite clinical pictures result from the "hyper" and "hypo" function states of all the important endocrines. In general the hyperfunction states have been up to now best attacked by surgical measures, and the hypofunctions by various extracts of the glands. The hypophysis seems to be an exception, in that surgical measures are not yet applicable to either acromegaly or Froelich's syndrome; but the overactivity of the insulin islands or adenomata of the insulin tissue resulting in hyperinsulism, has been successfully treated surgically. The epileptoid or collapse states accompanied by hypoglycemia have several times been cured by surgical

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removal of the offending pancreatic tissue (McAlenahan and Norris, Wilder and Finney).

Adrenal cortex hyperplasia and hypertrophy or true neoplasms of the cortical interrenal tissue give a characteristic clinical expression by causing paroxysmal hypertension, increased muscular activity, and stimulation of the sexual function. Patients having these conditions have been successfully operated upon and cured by removal of the adrenal adenomata. This condition represents the reverse of the hypofunction state known as Addison's disease (Mayo, Shipley, Porter).

Parathyroidism seems to be very frequent. Practically every journal of endocrinology or surgery now brings some report on cases of parathyroidism. In our own experience, we have 2 cases which were autopsied, showing the association of bone defects with parathyroid tumors. We performed during the last year, 5 parathyroidectomies, with improvement of the osteomalacic symptoms, and we have at least 20 other cases which clinically belong to this group. There is no doubt that this is a relatively frequent condition and that many people suffer from the lesser degrees of parathyroidism.

Parathyroidism is characterized by:

1. General skeletal disease with disappearance of lime salts from the bones generally and also in circumscribed areas, heretofore called osteitis fibrosa cystica.
2. Severe pains in the affected bones, especially the spine; elevated serum calcium, increased calcium excretion, reduced serum phosphorus and elevated phosphorus excretion.
3. Lessening in height of the patient due to compression of the vertebrae, curving of the long bones, and sometimes multiple pathological fractures.

As to the history of parathyroidism, Langendorf and Mommsen in 1877 and especially Virchow in 1886, gave very good pictures of osteitis fibrosa cystica, mentioning shortening of the patient's skeleton and softness of the bones and the localized

areas of so-called osteitis fibrosa cystica. Virchow especially stressed the point that these areas were not sarcomas, but areas of softening and not neoplastic in character. Von Recklinghausen in 1891, in a Jubilee Volume for Virchow, described osteitis fibrosa cystica, and Askanazy in 1904 first mentioned the association with parathyroid tumor.

Erdheim in 1907 connected the two findings etiologically in the publication of 3 more cases. In 1925, Hofferz collected 25 cases of osteomalacias with parathyroid tumor and Mandl in the same year, for the first time, successfully removed a parathyroid tumor, affecting a clinical cure of the condition. Since then about 20 cases of parathyroidectomy have been published where the calcium returned into the bones generally, and the fractures healed in the regions of the osteitis fibrosa cystica. There was immediate cessation of the severe bone pains after operation.

Early in 1930 Donald Hunter published an exhaustive discussion of the various clinical and pathological states associated with defects in calcium content of bone together with an exhaustive review of the question of calcium and phosphorus metabolism and the relation of the parathyroid function to the matter. Hunter's general conclusions are that the diffuse or multiple type of osteitis fibrosa cystica is definitely associated with parathyroid hyperfunction, usually a tumor-like hypertrophy or adenoma of one of the parathyroid bodies. In these cases it is the rule to find high blood calcium and low blood phosphorus with increased urinary excretion of both. On the other hand, Hunter regards osteomalacia, properly so called, and rickets, as essentially the same disease and different in etiology and pathogenesis from the osteitis fibrosa cystica associated with parathyroidism. He points out the seasonal and endemic features of osteomalacia and its relation to diet, to pregnancy and ovulation, and to irradiated ergosterol. He suggests that calcium and phosphorus by mouth along with appropriate dosage



with ergosterol leads to a cure, and does not by inference consider operative interference with parathyroids indicated in true osteomalacia.

Hunter recognizes the uniform occurrence of parathyroid hypertrophy in true osteomalacia, but regards it as compensatory or reactive in nature and not primarily responsible for the bone changes. We quote him as follows: "Osteomalacia therefore chemically resembles low calcium rickets. In the present state of our knowledge the occurrence of hyperplasia of the parathyroids in osteomalacia is without explanation. Since all parathyroids are usually affected the hypothesis that the change is compensatory seems attractive."

This author disposes of osteitis deformans or Paget's disease with the statement that Kay has found the serum phosphatase increased, but does not discuss a possible parathyroid relationship.

In osteogenesis imperfecta, the serum calcium, plasma phosphorus, and calcium output is normal. Hunter states, however, that Bauer and Dietrich have found enlarged parathyroids in this condition. In renal rickets there is a disturbance of endogenous calcium and phosphorus metabolism, probably on a nephritic basis. Hunter does not mention abnormalities of the parathyroids in this condition, although our autopsied case (*vide infra*) showed a huge hypertrophy of one of the parathyroid bodies. It would seem, then, that Hunter considers generalized osteitis fibrosa cystica with high blood calcium and low blood phosphorus to be fairly constantly associated with parathyroid adenomata, and to represent a true or primary hyperparathyroidism, justifying operative interference, but that most of the other states he regards as of other origin and considers the parathyroid hypertrophy to be of compensatory nature. Considering the high phosphorus retention of chronic nephritis and the fact that hypertrophy of the parathyroids is known to result from artificial production of a phosphotemia in young animals, it occurs to us that

possibly our parathyroid findings and the bone softening may result from this cause in renal rickets.

The clinical condition, which will probably keep the name of parathyroidism, (this will do just as well as the longer word, hyperparathyroidism) seems to become more and more established as a true entity. The affection starts at times as an isolated painful spot in the long bones, metacarpus, metatarsus, or most usually in the spine. A middle-aged patient will complain of backache, constantly increasing in severity, and that he is getting shorter. His head is sinking between his shoulders, his legs are becoming bowed, the costal arches approach the spine of the ilium more and more. The roentgenogram reveals a general deficiency of lime content of the bones. The plates look as though they were poorly taken, due to decrease of the shadow-giving calcium; and between this general demineralization, there is discovered here and there in the skeleton, areas with total absence of lime, resembling cystic formations (*osteitis fibrosa cystica*). In the long bones, tumor-like soft tissue swelling replaces the osseous tissue in irregular round or oblong areas and the vertebrae shrink in height and collapse. Severe pain in the affected bones ensues. Generally these pains are treated first with corsets to support the painful and stooped spine. The diagnosis of metastatic malignancy usually prevails until the duration of the symptoms makes this diagnosis untenable and further study reveals the parathyroidism. Studies of the calcium content of the blood render the diagnosis more convincing.

People around mid-life are mostly affected, but there are also some infantile cases reported beginning at about the age of eight to ten years. Whether the two are entirely of the same character remains to be seen. We know of 3 cases where the affection started in childhood.

For illustration it seems best to give some instances of our own observations and we shall choose those which were

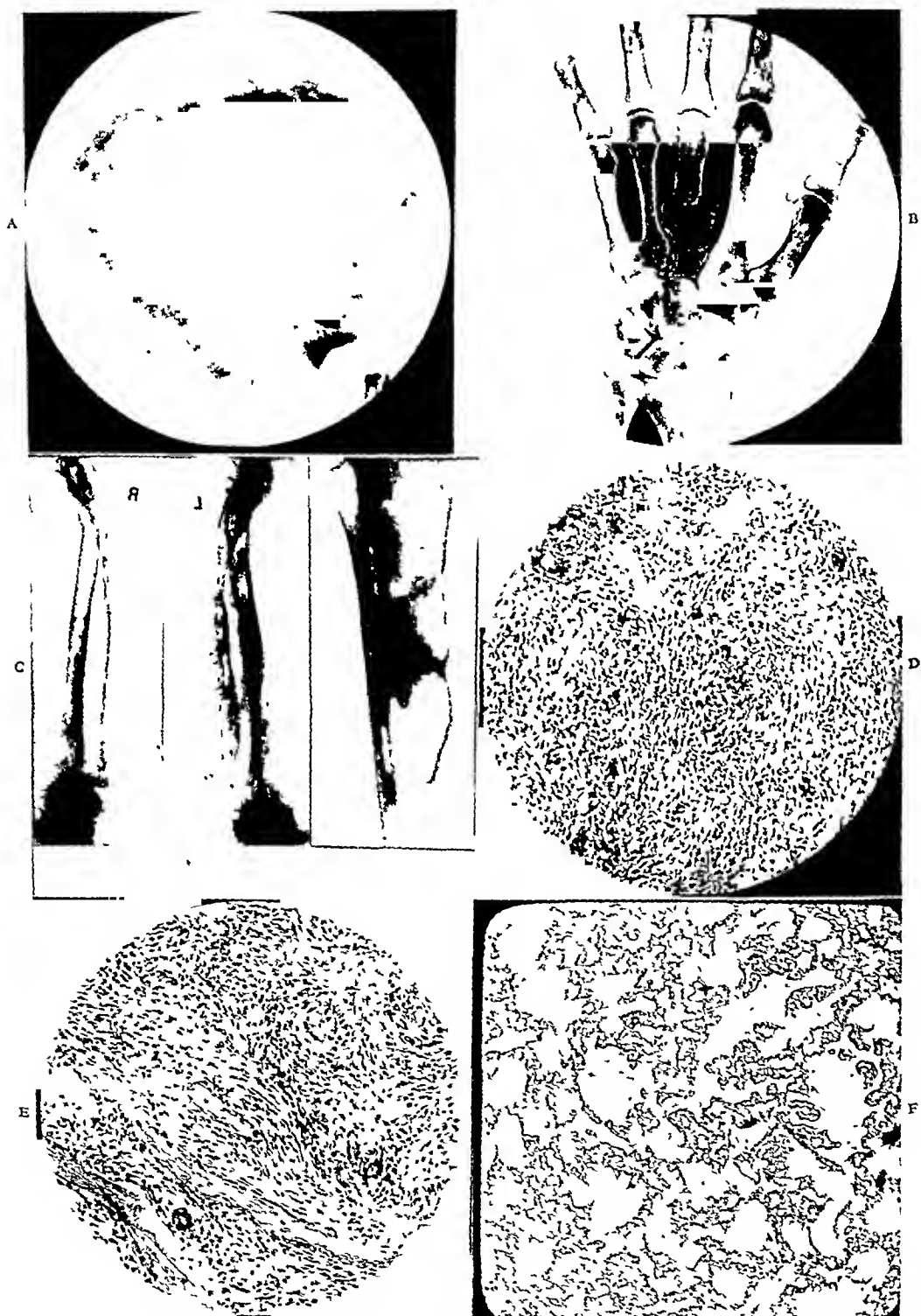
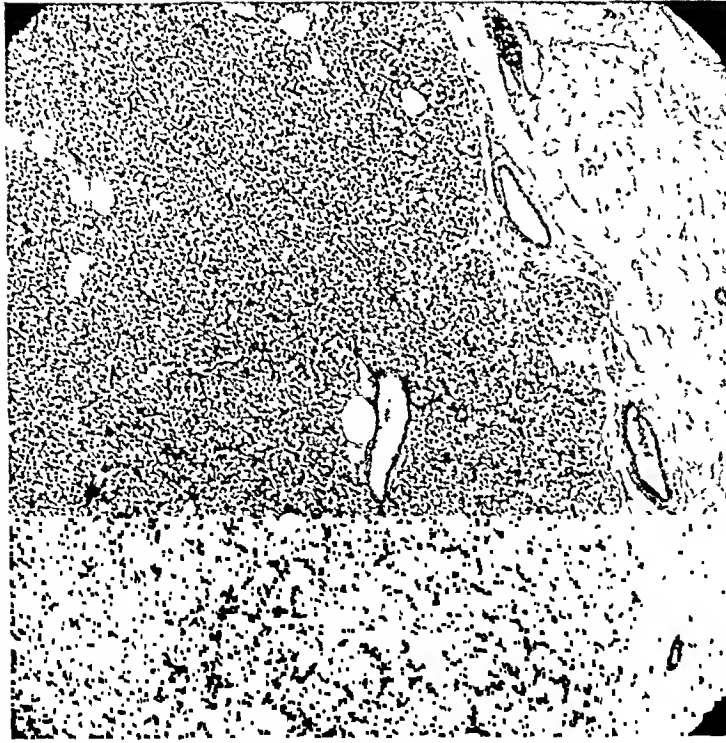


FIG. 1. Case 1. A. Skull cap demineralization. (Paget's disease of the skull.) B. Osteitis fibrosa cystica area in metacarpus. C. Osteitis fibrosa cystica in forearms and lower leg. D. Osteitis fibrosa cystica in cellular area resembling giant cell tumor. E. Osteitis fibrosa cystica; osteoid, fibrous area. F. Parathyroid tumor found at autopsy.



A



B

FIG. 2. Case II. Parathyroid hypertrophy in case of renal rickets.

proved to be of parathyroid origin, either by autopsy or operation.

**CASE I.** M. B. born November 19, 1875. In 1914 a swelling on the left forearm was noticed. Then followed swelling along the ribs. In 1915 the patient was unable to walk and had to use crutches, with much suffering from pain in the spine and legs. A cyst formation in the forearm was discovered in 1914. Other foci of osteitis fibrosa cystica were found in the legs. Arms as well as the legs were operated upon, and bone cyst scraped without influencing the process. A large fibroid was also discovered in 1920. She died in 1925 from an intestinal obstruction, the exact nature of which was not revealed.

Autopsy showed all bones very much thickened, irregularly deformed; the long bones showed bowing, could be bent like sole leather and cut easily with a knife. The cystic areas contained brown material, usually bleeding and sponge-like. The normal structure on other places was replaced by yellowish gray fibrous tissue. The periosteum was very thick. The skull cap was  $\frac{1}{2}$  in. thick, cut easily with a knife, and the layers of the skull could not be differentiated. The left parathyroid contained a tumor.

**Comment:** In this case, the affection started as mentioned before, and as so often happens, as an isolated swelling of osteitis fibrosa cystica in the left forearm, followed later on by multiple foci in the ribs, pain in the spine and legs and general demineralization with many cystic areas in the bones. The skull cap could be cut with a knife, which also was true in the second autopsy case. A parathyroid tumor in this case was not suspected before death, and was only discovered at autopsy. Repeated attempts were made with this patient prior to 1925 to produce a positive calcium balance by feeding calcium lactate and calcium chloride without success. Repeated curettements of affected areas were without success in causing bone formation.

**CASE II.** E. H., aged seventeen, admitted to Harper Hospital on September 4, 1930, died September 13, 1930. His chief complaints were weakness, loss of weight, anemia, and fever. From the physical examination we mention

the following: High blood pressure for his age, 178/92, deep brown discoloration of the skin, systolic murmur at heart, slight enlargement of the liver and spleen, hypospadias, with scars of several operations, precordial frictional rub, oliguria with albumin, red and white blood cells, hyaline and granular casts in the urine, and very high blood nitrogen. The case corresponds clinically to the condition known as renal rickets. The clinical diagnosis of this case was hypertensive nephritis. The bone lesions were unsuspected and no x-ray examination or calcium or phosphorus estimations were made. The true nature of the case with the bone softening and parathyroid hypertrophy was found at autopsy.

On autopsy the most striking finding was the softness of the bones, the skull and cranium could be cut with a knife, and again there was a generalized hypertrophy of the parathyroids, extraordinary hyperplasia of eosinophils and basophils in the pituitary and extreme arteriolar degeneration of the kidneys (Joré's type). Pemberton and Geddie published practically an identical case in a girl fourteen years old with calcium deficiency in the bones and finding of an adenoma of the left lower parathyroid body. Also this case was complicated with polyuria and slight albuminuria.

**Comments:** Besides this case, we have two more observations (Cases I and VI) where the disease started early in life. Whether this type of parathyroidism is entirely the same affection as that usually coming on at mid-life remains to be seen, but appears likely.

**CASE III.** J. B. came under the observation of our associate Dr. R. C. Moehtig in 1927, when he was about sixty-five years old. The patient noticed that he was stooping over, had severe pain in his spine so that he had to take opiates. X-rays showed a destructive process; the bodies of the vertebrae diminished in height, and there was general decalcification so that the bones did not stand out well. A diagnosis of metastatic malignancy was made at first, but the process went on for three or four years, without much change except that the pain became much more severe and more bones became affected. Dr. Moehtig diagnosed the case as parathyroidism. The patient was operated on by Dr. Ballin on May 31, 1930.

Figure 3, D, E, and F shows the parathyroid

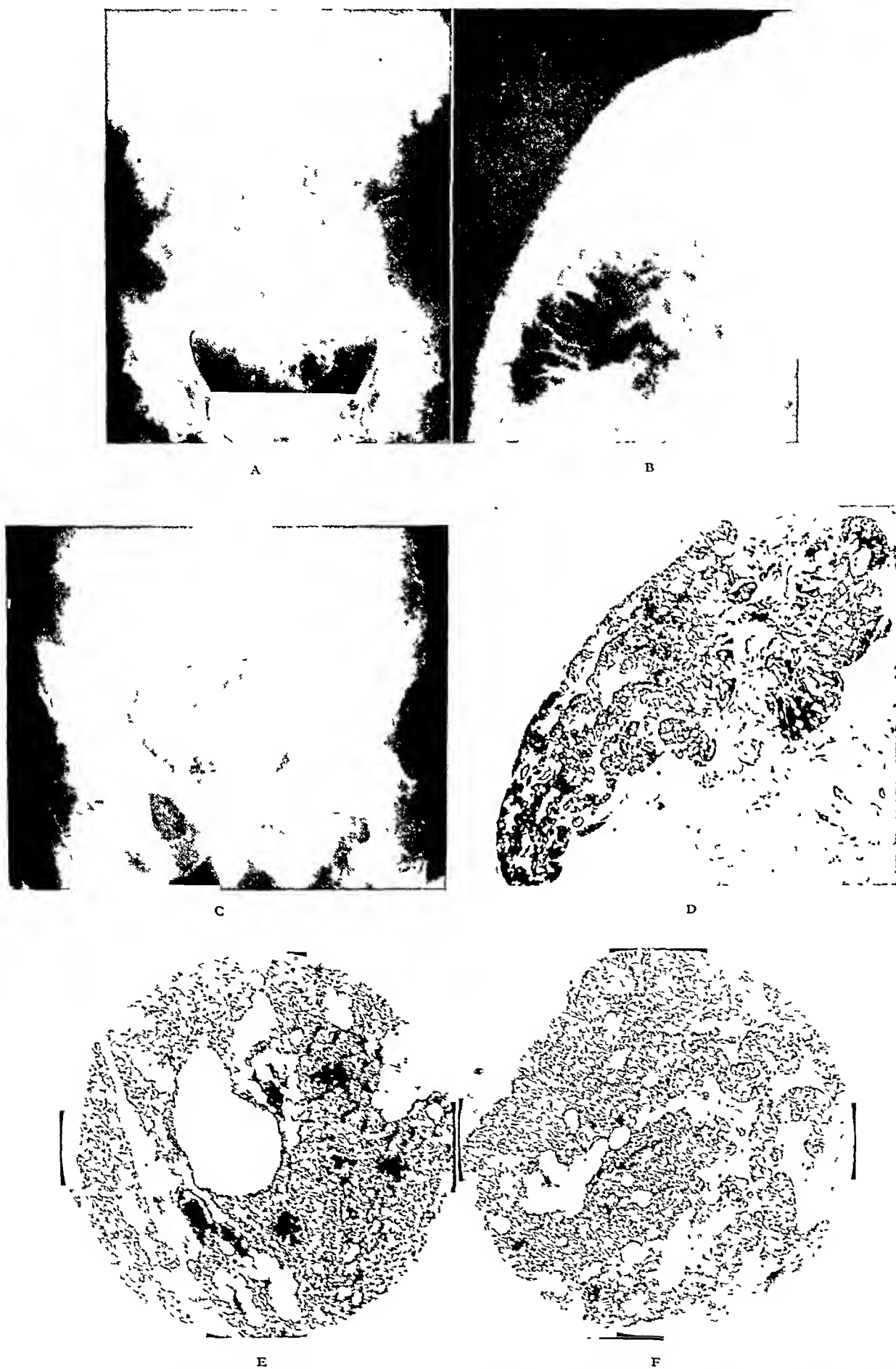


FIG. 3. Case 111. A. Collapsed vertebrae before operation. B. Collapsed vertebrae before operation. C. Calcium coming back into bones, four months after operation. D, E and F. Microphotographs of the parathyroid bodies removed.

tissue removed. Figure 3c shows the calcium coming back in the bones, four months after the operation. The pain has practically dis-

then x-ray evidence of a destructive process in the vertebrae is found. In practically every case the condition is first considered

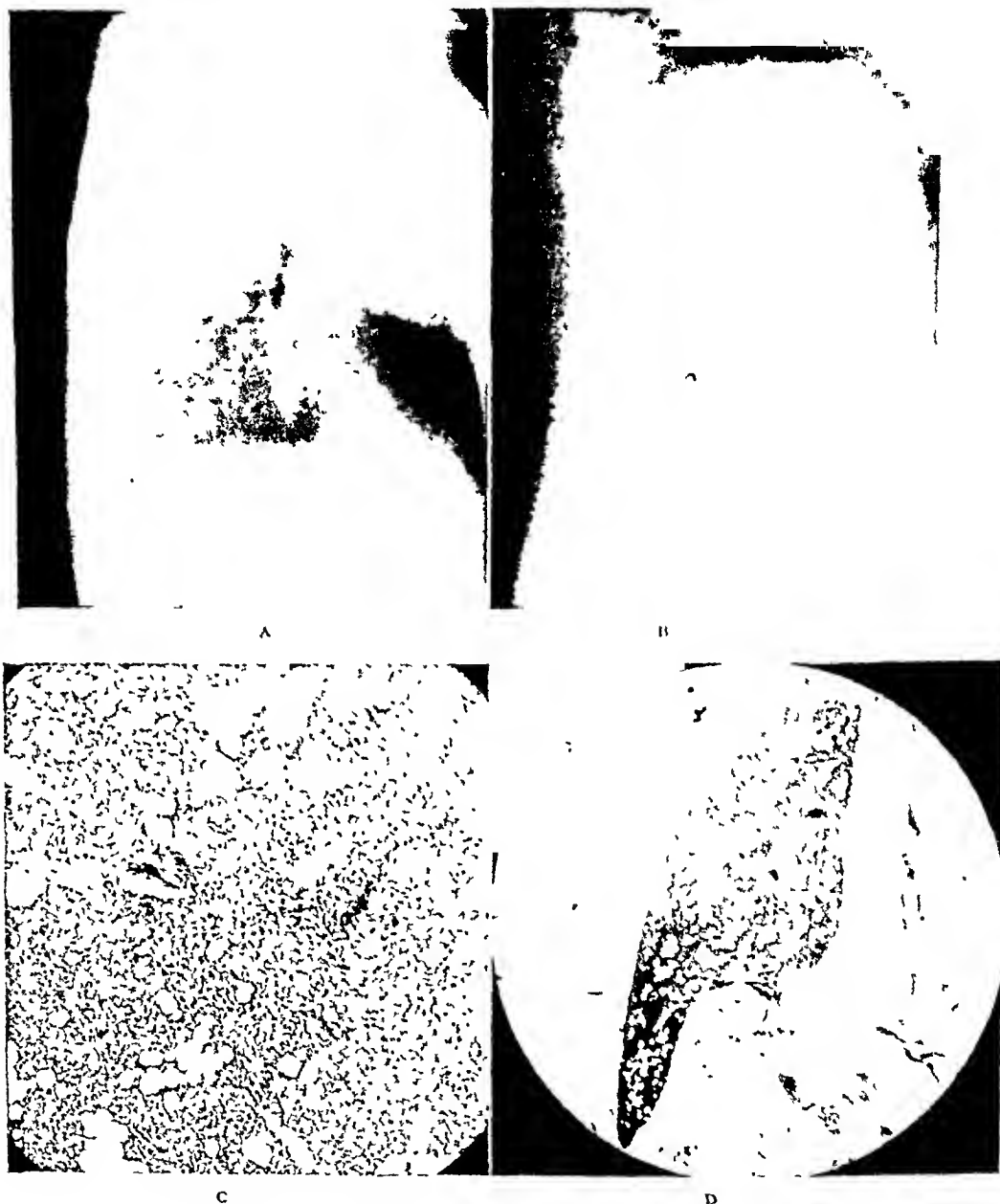


FIG. 4, Case IV. A. Collapsed vertebrae. B. Collapsed vertebrae. C. Parathyroid body with round cell infiltration. D. Parathyroid body, low power.

appeared so that the man does not need opiates any longer. The stooping is no longer progressive but is stationary.

**Comment:** The case of Mr. B. is very interesting and shows the typical history of a patient becoming at first weak, then getting backache, becoming stooped, and

malignant metastasis. No primary malignancy can be found and finally parathyroidism is thought of. It is quite characteristic that in all cases, at least those in mid-life, some arthritic process of the spine and sacroiliac joint is first claimed, but the usual support of the

sacroiliac joints and spine does not give results. The calcium readings are frequently normal at times, but then again we get readings of 14.0 and 16.0 and this confirms the diagnosis. The parathyroids do not have to form actual tumors (adenomas). A simple hyperplasia is sufficient to produce the picture.

**CASE IV.** The case of Mr. R. C. is practically identical with the preceding case. This man, who was healthy all his life, began to complain of pain, which was first called sacroiliac distress. Some hypertrophic arthritis was found in the x-rays, for which he had some teeth extracted. The process progressed clinically as well as in the x-ray findings. Five months after the onset, the arthritic process was found in the thoracic and lumbar vertebrae and in addition a generalized osteoporosis. At two hospitals the diagnosis of malignancy and myeloma, respectively, was made. Eight months after the onset, Dr. William Evans roentgenologist at Harper Hospital, suggested that the condition belonged to the parathyroid group. On September 13, 1930, thyroparathyroidectomy was performed by Dr. Ballin. Three parathyroid bodies were removed. The pain was influenced immediately, and now five months after the operation, the man is coming back to normal activity.

Figure 4, A and B, shows the collapsed vertebrae. Note the general compression of the vertebral bodies; they are not cone-shaped as in fractures and malignancy, and also note the demineralization. The calcium in Mr. C's case was around 12.0 to 14.0 and once was 18.0 and again 20.0 at different readings. It seems that one reading of calcium should not be the deciding factor.

*Comment:* Again a case in an adult, after mid-life, who complained of typical back and leg ache. The condition was first diagnosed as sacroiliac arthritis, then the changes in the vertebrae were found and the patient treated for malignancy of the spine and myeloma and was supported with a corset until the eye of an experienced x-ray man discovered the difference in the collapsed vertebrae, the same being not wedge-shaped as in malignancy or in fracture, but generally compressed. While not absolutely diagnostic,

and subject to various exceptions, the finding of a uniformly compressed rather than a wedge-shaped or irregular vertebral disc seems to be suggestive of parathyroidism. Dr. Wm. A. Evans is to be commended in teaching us to recognize this differentiation. The pains were so severe that the patient had to take codeine for a long time. Immediately after the operation the pain disappeared, and the latest x-rays, six months after operation, show a return of calcium into the bones.

**CASE V.** Mrs. M. enjoyed good health up to the age of sixty, when she complained of symptoms of thyroidism. A calcified adenomatous goiter was removed in 1927. Palpitation and the thyroidism ceased but in 1930 she showed a deficiency of calcium in the scaphoid of the right foot (osteoporosis). There was still a high metabolic rate of 25 per cent above normal. The calcium at different times was from 6 mg. to 11 and 12 mg. The patient had to walk with crutches. Later on the process extended into the spine as in the other cases. On December 13, 1930, two parathyroid bodies were removed showing on microscopical examination, typical parathyroids with cystic degeneration and some lymphoid infiltration. The operation resulted in immediate disappearance of the pain and the woman is walking again without crutches.

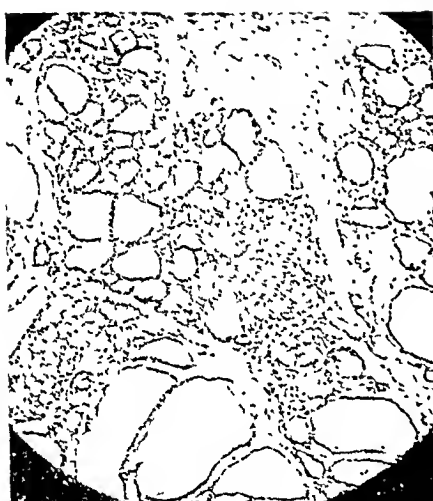
*Comment:* Again a case where the affection started in one bone. For two or three years this lady had no other symptoms but pain in the foot and osteoporosis showed in the scaphoid of the right foot. Then the backache and leg ache supervened. It is also interesting that this woman, as in nearly all our other cases, had a goiter at the same time. This goiter was removed three years before the parathyroidectomy. Hunter in his article mentions that thyroidectomy also has an influence on the calcium metabolism and will improve parathyroidism. Whether this is actually the result of the thyroidectomy or whether in removing the thyroid tissue, the parathyroids were included, remains to be seen. Anyway, this patient got her parathyroidism after the thyroidectomy.



A



B



C



D



E

FIG. 5. Case v. A. Beginning crushing of dorsal vertebrae. B. Osteoporosis in scaphoid. C. Microphotograph, showing adenomatous goiter associated with parathyroid hypertrophy. D. Microphotograph of thymus enclosure in parathyroid region. E. Microphotograph of parathyroid adenoma.



CASE VI. Another case, a colored woman, aged thirty, who had had an osteomalacic process (osteitis fibrosa cystica) in the femur and left pelvis since the age of ten years. The result of a spontaneous fracture can be seen in the pelvis and femur. Other pathology in the osseous system is a fracture in the left humerus, which happened without causing any great pain. This woman's pain in the hips and pelvis had been very severe for the last ten years so that she could not do her work. Parathyroidectomy gave immediate relief from the pain.

This woman at the time of operation was thirty years old, but she had her osteitis fibrosa cystica and spontaneous fracture in the femur and the pelvis at the early age of ten years. Pain in the vertebrae and back followed later on. It is to be regarded as one of the cases in early life.

CASE VII. A woman past mid-life, began to get stooped and had great pain in the back. Blood calcium was 14 and 18 mg. X-rays showed the curvature. The removal of three parathyroids gave immediate relief of the pain.

This case is just mentioned as it shows the good result from operation. Otherwise it resembled Cases III and IV. This woman also had an enlarged thyroid gland.

In these cases, the usual symptoms of parathyroidism are evident, namely a general deficiency of lime content of the bones, with localized areas of so-called osteitis fibrosa cystica, severe pains in the affected bones, especially in the back and down the legs, also pain in the isolated areas of decalcification, and the manifestation of general and local decalcification in the x-ray, and by the laboratory finding of high serum calcium, and reduced serum phosphorus. Such symptoms should lead to the diagnosis of parathyroidism.

Excluded from this diagnosis should be all cases of metastatic malignancy, myeloma, and carcinoma, following cancer of the breast or prostate, etc. The radiologists point out that metastatic processes go with increased calcium content in the affected areas, where parathyroidism shows lessened calcium. Cancer metastases in the vertebrae show a triangular V-shaped compression, and the fractured vertebrae also have

this shape. In parathyroidism, the whole body of the affected vertebrae is compressed and lower than the normal vertebrae.

Patients with parathyroidism usually show other endocrine stigmata, showing a general upset in the endocrine system and practically all have more or less of a goiter.

Just how much there will be left to the chapter of osteitis fibrosa cystica and Paget's disease of the bones if this whole territory belongs to the group of parathyroidism, cannot be settled until more observations are on hand. Suffice it to say that these symptoms should be an indication for a parathyroidectomy, if the symptoms are pronounced enough, and the pain sufficiently incapacitating to warrant surgery.

Feeding of lime salts and cod liver oil containing special vitamins has not proved successful for combating the symptoms but should perhaps be used in the after-care of the operated, to replace the calcium. However, replacement of calcium by feeding by mouth does not seem to increase the calcium content of bones and blood. Intravenous medication seems to be preferable.

As to the technique of the operation, the parathyroids are approached just as in goiter operations. By turning the thyroid lobe over to the opposite side careful dissection will lead down to the point where the parathyroids can be exposed between the carotid and thyroid near the inferior thyroid artery. We find pretty constantly a lower parathyroid and a little further up an upper parathyroid. Four parathyroids seem to be fairly constant. Most patients are operated on by thyroparathyroidectomy, which means that a subtotal lobectomy is done first; then the parathyroids can be better exposed and further some enclosures of parathyroid tissue in the thyroid are removed with the lobectomy. There is also the opinion expressed by many that the thyroid itself sometimes takes a part in the decalcification of the bones. Whether this is the actual function of the thyroid or due to parathyroid enclosures is still doubtful.

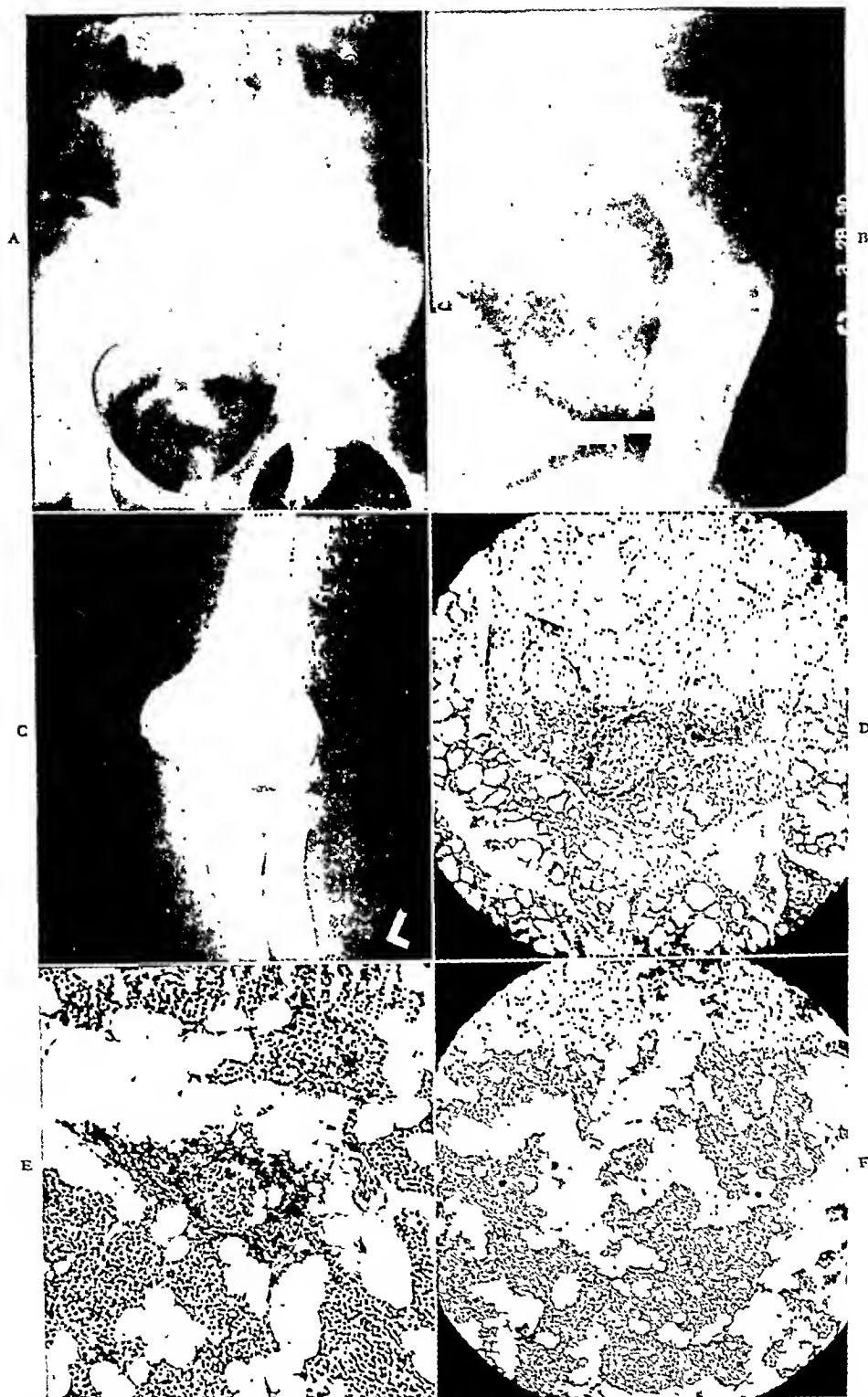


FIG. 6, Case VI. A. Pelvic bone lesions. B. Femur showing decalcification. C. Demineralization in bones of arm. D. Adenomatous thyroid associated with parathyroid hypertrophy. E and F. Parathyroid tissue with round cell infiltration and adenomatous areas.

From Hunter's work it would seem probable that a definite type of osteoporosis associated with hyperthyroidism (exoph-

or better intravenously and if there is only one parathyroid left, the patient seems to come into complete equilibrium of para-

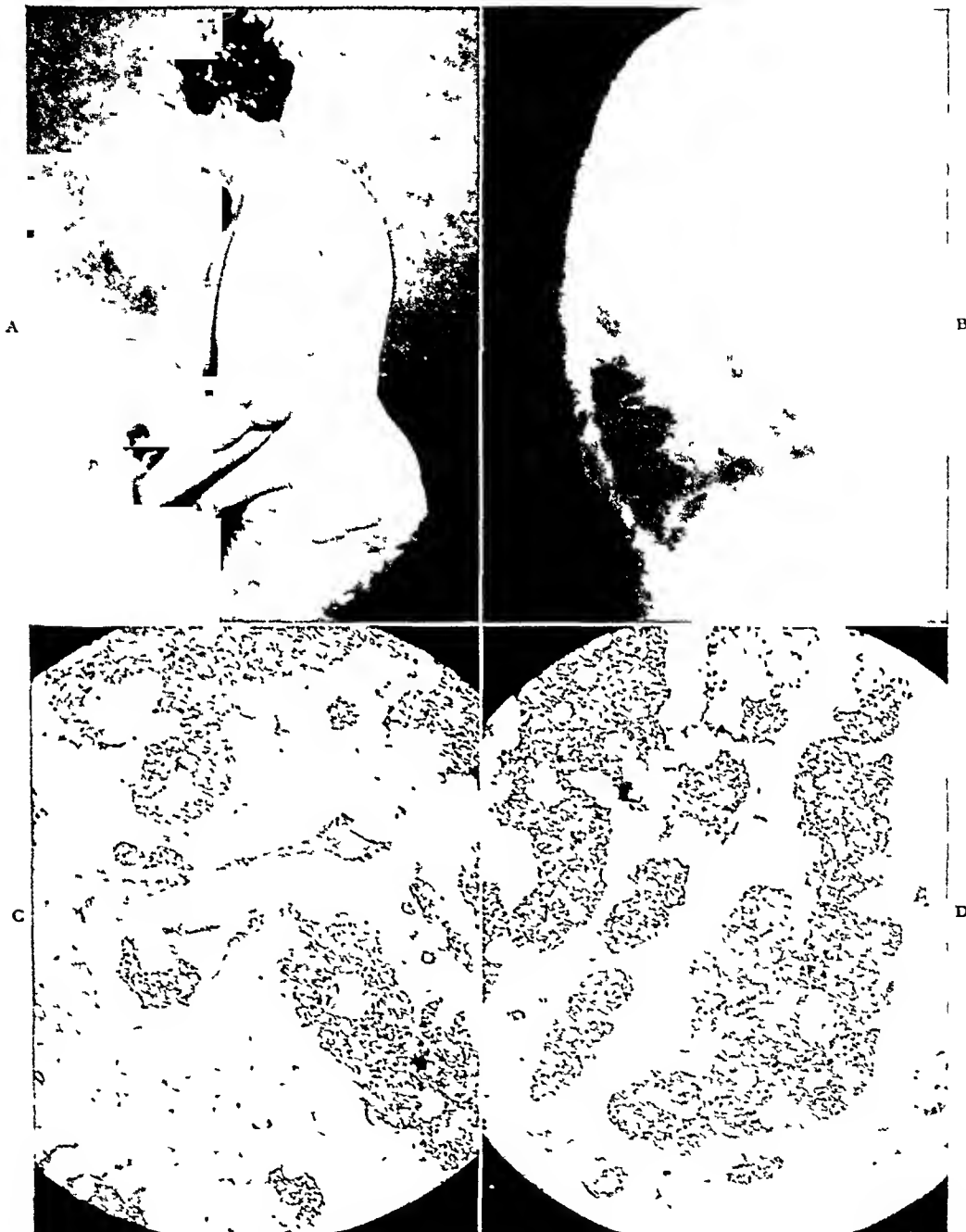


FIG. 7, Case VII. A. Bowing of back and shortening of stature. B. Flattening of vertebrae. C. Adenomatous parathyroid tissue. D. Adenomatous parathyroid tissue.

thalmic goiter) and characterized by a low rather than a high blood calcium will have to be recognized.

In the postoperative period, the patient should immediately be administered 20 units of Collip's extract per day; later on calcium products are given by mouth

thyroid function within a very few weeks. Most astonishing is the almost immediate cessation of the most severe pain, which must be due to endocrine changes, because as far as the x-rays show, the return of calcium in the softened bones takes from three to seven months after the operation,

but the cessation of pain and the gain of weight start practically immediately.

### CONCLUSIONS

1. Parathyroidism seems to be a very frequent affection and will be encountered often if the symptoms are looked for and interpreted properly; at least a lesser degree of the condition seems to be very frequent.

2. General demineralization of the bones, due to deficiency of calcium, in addition to localized cystic areas usually with severe

pain in the bones, especially in back and legs, is the rule. The combination of these bone changes with high blood calcium and lowered blood phosphorous, should be sufficient reason to investigate the parathyroid area for tumor or hyperplasia of the parathyroids.

3. The parathyroid tumor or hyperplastic gland should be removed in such patients. This operation seems to be fairly safe under proper after-care with the administration of parathyroid hormone, (Collip's extract) and later on calcium preparations.

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## ROENTGENOGRAPHY AS AN AID IN OBSTETRICAL DIAGNOSIS\*

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**A**LTHOUGH roentgenography has been employed to the utmost advantage in medicine and surgery, it has not been sufficiently utilized in the field of obstetrics. Yet roentgenography in obstetrics, as compared with the ordinary methods of physical examination, gives such accurate and definite information that it should be regarded as a necessity in every maternity institution or hospital where obstetrics is practiced.

One reason why it has not been more generally employed may be the knowledge that therapeutic doses of x-rays have a deleterious effect on the fetus, frequently resulting in deformities. This objection is no longer valid, since diagnostic roentgenography has been accepted and recognized as a harmless procedure. Most observers now agree that there can be no possible danger to mother or child from the brief exposures required to obtain roentgenograms, provided they are not too often repeated. This has been amply proved by the work of Reinberger and Schreier.<sup>1</sup> According to Garland,<sup>2</sup> who made a careful survey of the literature, no single case of injury to either fetus or mother following the use of x-rays for purely diagnostic purposes has ever been reported.

Another reason for the delay in adopting roentgenography as a routine diagnostic procedure is probably the fact that many of the methods that have been proposed have appeared so cumbersome and complicated that obstetricians have regarded them as rather impractical. This obstacle to the use of roentgenography in cases in which it is indicated has been surmounted by the development and simplification of the technique.

Roentgenography has been shown to be

especially valuable in obstetrics in the diagnosis of pregnancy in obscure cases, the recognition of twins, the differentiation between pregnancy and tumors, the diagnosis of tubal and ovarian pregnancy, and in revealing the presence of a fetal monster. It has also proved its value in supplying a more accurate method of pelvimetry than any heretofore proposed, in furnishing a method of cephalometry in utero, in giving information as to the presentation and position of the fetus, and in demonstrating the mechanism of labor.

In reviewing the history of pelvic roentgenography it seems that the first results obtained by roentgenograms in obstetrics were not encouraging. In 1897, Levy-Dorn<sup>3</sup> recognized the skull of an eight months' fetus in utero by means of a roentgenogram, and the following year Müllerheim<sup>4</sup> described a similar finding. Other obstetricians, however, after making exposures lasting one and one-half hours, reported failure to secure any definite results. In 1908, Bouchacourt<sup>5</sup> came to the conclusion that it was impossible to secure a roentgenogram of a living fetus, or that if a shadow was secured, it was a sign of fetal death.

Albers-Schönberg,<sup>6</sup> in 1904, so improved the technique in roentgenography that its use became more popular in obstetrics. Later Bartholomew,<sup>7</sup> Sheuton,<sup>8</sup> Horner,<sup>9</sup> and Candy<sup>10</sup> showed that the diagnosis of pregnancy could be definitely made after the fifth month.

### DIAGNOSIS OF PREGNANCY BY ROENTGEN RAYS

Ordinarily the diagnosis of pregnancy can be made earlier by clinical methods than by roentgenography. In cases of fibroids and other conditions simulating

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pregnancy, however, x-ray study may help in differential diagnosis.

This is illustrated by the case of H. C.,

tender, no fetal parts were felt, no fetal heart sound could be elicited, and no fetal movements were observed. There was



FIG. 1. Flat roentgenogram, taken with patient lying on her abdomen, showing six and one-half months' pregnancy with left breech presentation.

aged forty, who complained of amenorrhea and increasing size of the abdomen. She had one child, fifteen years old. She had been operated upon one year previously. Three months before the operation, she had had a therapeutic abortion induced because of a large fibroma. After the abortion, she had a fever and had to be removed to the hospital. A month later a laparotomy was done. She was under the impression, which later proved erroneous, that she had a hysterectomy done for a fibroid uterus and a large dermoid cyst. After the operation, she had some scanty bleeding every month. During the last six months, the monthly bleeding ceased and she noticed that her abdomen was growing larger. A diagnosis of ovarian cyst was made by her physician. It was impossible to obtain a correct report of the nature of the operation.

The physical examination was unsatisfactory: The abdomen was very tense and



FIG. 2. Four and a half months' pregnancy. In this case, clinical examination could not establish the diagnosis of pregnancy and only the roentgenogram saved the patient from a hysterectomy on the supposition that the condition was one of fibroids. (Slightly retouched.)

only a suspicion of the presence of internal ballottement.

A flat roentgenogram with the patient lying on the abdomen (see Fig. 1) showed a six and one-half months' pregnancy with a right breech presentation.

In another case (see Fig. 2) the history and physical examination strongly suggested a condition of uterine fibroids. The roentgenogram revealed a four and a half months' pregnancy and thus saved the patient from an unnecessary hysterectomy.

Figure 3 illustrates a similar case in a five months' pregnancy.

The diagnosis of pregnancy can be made by recognizing the fetal bones roentgenographically as early as the fourteenth week. With proper preparation and careful technique, it is often possible to demonstrate the fetus during the third month.

Leiser,<sup>11</sup> of Warnekros' clinic at Dresden, reports the use of the x-ray for the early diagnosis of pregnancy in 61 cases. The Potter-Bucky diaphragm was used with a current of 100 ma. and an exposure of two and one-half seconds. A ventrodorsal

exposure was usually employed and occasionally a dorsoventral exposure as well. In a few instances the latter demonstrated the presence of a fetus when the former gave negative results.

Of the 61 cases studied, there were 41 in which the presence of a fetus was clearly demonstrated; and in 1 of these cases, the diagnosis of pregnancy, as against that of an intra-uterine tumor, was established. In 20 cases no fetus was demonstrated; in 2 cases a diagnosis of myoma was made and proved correct at operation; in 4 cases a subsequent curettage showed only placental tissue. In 14 cases pregnancy was not demonstrated although diagnosed clinically. In all of these cases examination was made in the eighth to twelfth week of pregnancy. In the 41 cases in which a definite roentgenological diagnosis was made, the pregnancy was in the fourteenth to twentieth week.

It was not possible, therefore, to make a diagnosis of pregnancy prior to the fourteenth week; but the method did not fail after that time. Obesity or the coexistence of a tumor does not prevent the correct diagnosis of pregnancy after the fourteenth week. At this period all the fetal bones are not necessarily shown in the roentgenogram. Sometimes only a few vertebrae, ribs, or bones of the extremities are visible; the fetal head is less frequently shown than the vertebral column. The position of the fetus in utero can, however, be determined.

Jungmann's<sup>12</sup> method for the demonstration of early pregnancy includes the use of the Potter-Bucky diaphragm. As a rule, the rays are directed axially through the pelvis from in front and above downward and backward, as for an axial roentgenogram of the bladder. In this way, the maternal bones are not shown except for a small portion of the lower part of the sacral bone and the coccyx. In some cases, the patient is put in the oblique half-dorsal position and the rays are directed from an antero-inferior position on the left side backward and upward to

the right side. This method is used when the uterus is high.

In early pregnancy, only some of the



FIG. 3. Five months' pregnancy. In this case, clinical examination could not establish the diagnosis of pregnancy and only the roentgenogram saved the patient from a hysterectomy on the supposition that the condition was one of fibroids. (Slightly retouched.)

fetal bones are demonstrable. The vertebrae and ribs are most frequently shown, their arrangement and appearance depending upon the position of the patient and the direction of the rays. With his method Jungmann has found it possible to demonstrate pregnancy in the eighth to the ninth week in some cases. From the tenth week on he has been able to demonstrate pregnancy as a rule, except under especially difficult circumstances.

For the diagnosis of early pregnancy by x-ray, Dujol and Michelin<sup>13</sup> use a 40 ma. current, the Potter-Bucky diaphragm, and an exposure of two to four seconds. The patient is placed in the dorsal decubitus and the tube inclined at 35° as for roentgenography of the bladder, in such a way as to enlarge the image of the pelvis and thus facilitate demonstration of the presence of the fetal bones.

In 34 cases studied in pregnancies of twenty-two weeks or less, there were 11 cases in which no fetal skeleton was demonstrated. In no instance was it demonstrated

before the fourteenth week, but in one case a clear image of the fetal skeleton was obtained in the fourteenth week, an un-

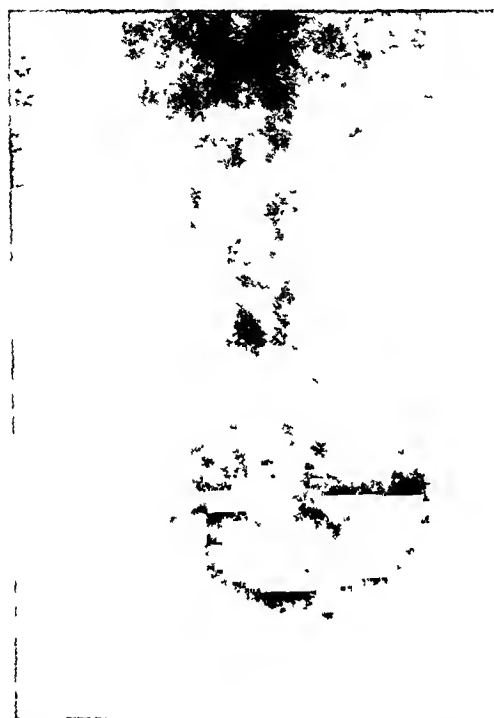


FIG. 4. Twin pregnancy. Only the roentgenogram disclosed the true condition. (Slightly retouched.)

usual and remarkable picture. In the fifteenth week, 2 cases were examined, both positive; in the sixteenth week, of 3 examinations 1 showed the fetal skeleton clearly and 2 rather indefinite shadows suggesting a vertebral column in one instance and a head shadow in the other.

In this group of cases studied by Dujol and Michelon, a definite diagnosis of pregnancy as against tumor was made by demonstration of the fetal skeleton. In 3 cases the presence of a dead fetus was demonstrated.

Bouchacourt<sup>5</sup> is of the opinion that roentgenographical diagnosis of pregnancy cannot be made before the third to the fourth month. Then the fetal skeleton is always demonstrable, but in normal cases roentgenography is not necessary for the diagnosis of pregnancy at that time. It is of value in the later months of pregnancy, however, in determining the position of the

fetus; in the diagnosis of twin pregnancy and fetal malformations, such as hydrocephalus; and for the diagnosis of the death of the fetus in utero. It is also of value for the diagnosis of tumors complicating pregnancy, and for measurement of the size of the fetal head in relation to the pelvis.

For roentgenological study of the pregnant uterus, Bouchacourt<sup>5</sup> uses, as a rule, the Potter-Bucky diaphragm with the patient in ventral decubitus. Lateral views are also of definite value in the late stages of pregnancy, as they avoid the superposition of the maternal on the fetal skeleton.

Jaubert de Beaujeu<sup>14</sup> has not employed the Potter-Bucky diaphragm for the early diagnosis of pregnancy, but has directed the rays very obliquely with a short focal distance with instantaneous exposure. The patient is in ventral decubitus and the film with two intensifying screens covers the subpubic rectangle. The rays are directed obliquely from behind forward in the line of the neck of the femur and from above downward so as to pass in front of the coccyx. Lateral exposures may also be made. The images obtained are deformed and enlarged, but sufficient to demonstrate the presence of the fetal bones. This method avoids a superposition of the maternal bones on those of the fetus. By this method it was found possible to demonstrate the fetal bones from the third to the fourth month. The earliest pregnancy in which this was done was three months and ten days.

#### DIAGNOSIS OF TWIN PREGNANCY

The diagnosis of multiple pregnancy during the earlier months often presents difficulties. In such cases roentgenological study clears up all doubt.

Figure 4 shows a twin pregnancy at term. In this case two fetal hearts could not be heard, nor was there a multiplicity of fetal parts detectable on palpation. Only the roentgenogram disclosed the true condition.



Figure 5 is the roentgenogram of a woman, seven and a half months pregnant, over whose abdomen fetal heart sounds

several distant areas, it was the roentgenogram which proved that only one fetus was present.



FIG. 5. Normal pregnancy at seven and a half months. On physical examination, it was impossible to make out the presenting part. As fetal heart sounds were heard in several areas, the possibility of twins was suspected. The film shows one fetus only, in the left occipito-transverse position.

were heard in several areas. The possibility of twin pregnancy was therefore suspected. However, the film showed only one fetus, in the left occipito-transverse position. In this case it was impossible to locate the presenting part by physical examination.

The lateral view is of particular value in the recognition of twin pregnancy (Grier).<sup>15</sup> The procedure, however, may be difficult. The abdomen is usually large and the quantity of amniotic fluid great. In early pregnancy, it may be impossible to demonstrate the fetal bones in the anterior view, but they may be seen in the lateral view.

I have observed several cases in which only the roentgenogram disclosed the existence of twins. In other cases, where there appeared to be a multiplicity of fetal parts and fetal heart sounds were heard in

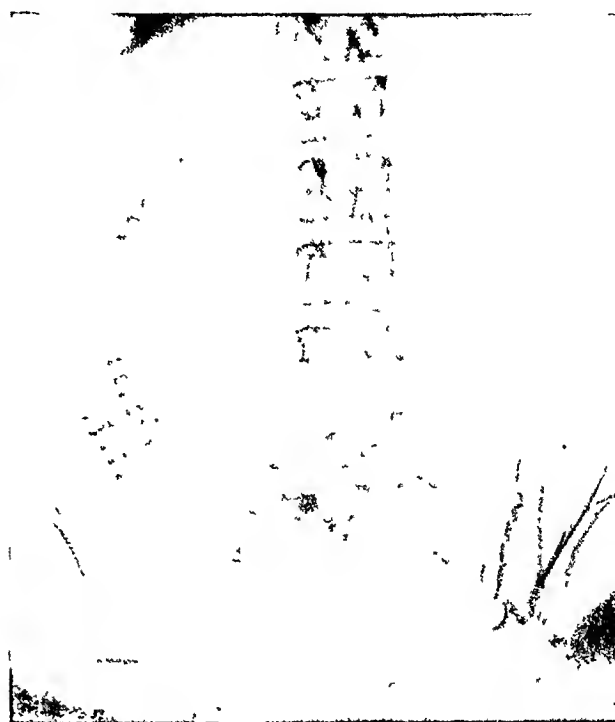


FIG. 6. Right occipito-posterior presentation, eight months' gestation.

#### DIAGNOSIS OF POSITION AND PRESENTATION OF FETUS

X-ray films after the sixth month clearly show the presentation, position and posture of the fetus.

In Figure 6 a right occipito-posterior presentation in an eight months' gestation is clearly revealed. Figure 7 shows a left occipito-transverse position with marked overriding in a patient who was in labor twenty-four hours and overdue.

Face presentation at term is clearly shown in Figures 8 and 9.

Nölle<sup>16</sup> has found the x-rays of definite value in determining the position of the fetus and in the diagnosis of twin pregnancy and of fetal malformations, especially in the presence of hydramnios. In 2 cases he was able by this means to diagnose an anencephalus prior to labor. An irregular bony formation was shown above the cervical vertebrae corresponding to

the base of the skull; the vault of the skull was entirely absent.

Blanche<sup>17</sup> (1927) states that he has

In the later months of pregnancy, with good technique the fetal skeleton is usually shown in its entirety. This makes it possible



FIG. 7. Left occipito-transverse position with marked overriding; patient twenty-four hours in labor and overdue.

demonstrated the fetal bones in utero as early as three months and a half in pregnancy and in 1 case in which the pregnancy was only a few days over the third month, but in another recent series of examinations he was not able to obtain definitely positive roentgenographical evidence of pregnancy until toward the end of the fourth month. In those cases in which the fetal bones were demonstrated in the roentgenogram before the fifth month of pregnancy, the cervico-dorsal portion of the vertebral column was most frequently visible and also the points of ossification of the head, especially the occipital; much more rarely the ribs and only exceptionally one of the long bones could be seen. The presence of the fetal skeleton can be demonstrated about three weeks before there are clinical signs of fetal life.



FIG. 8. Left mento-posterior position at term. Patient in labor three days; ruptured membranes; marked Bandl's ring; cesarean section done with peritoneal exclusion. Anterior view.

to determine the position of the fetus in utero before labor and the exact position of the head in relation to the superior strait.

Roentgenography in the later months of pregnancy also shows the presence of twins, of fetal anomalies, and of fetal death; it makes it possible to differentiate a tumor from pregnancy and also as a rule to diagnose the presence of a tumor complicating pregnancy. Blanche<sup>17</sup> has not found roentgenography of value in the diagnosis of extra-uterine pregnancy, unless it has become encysted or calcified (lithopedion).

In the roentgenography of the pregnant uterus, he has found the best technique to include the use of a 60 to 80 ma. current with hard rays (70 to 80 kv.) and the

Potter-Bucky diaphragm, with exposure of one second. The patient is in the ventral position, as a rule, but lateral views are

Albano<sup>19</sup> reports a case in which a diagnosis of hydrocephalus with the fetus in breech presentation was made in the



FIG. 9. Same as Fig. 8, posterior view.

taken in some cases. In early pregnancy the x-rays should be centered on the axis of the pelvic cavity.

#### DIAGNOSIS OF ABNORMALITIES OF THE FETUS IN UTERO

The recognition of monstrosities is greatly aided by x-ray examination (Grier<sup>15</sup>). This subject has been covered in great detail in a monograph by Dorland and Hubeny.<sup>18</sup> Both anteroposterior and lateral views are indispensable for this purpose.

Anencephaly has been recognized from the anteroposterior view; but for the detection of abnormal development of other parts of the skeleton the lateral view is more valuable. Absence of the vertebrae and bones of the pelvis, decrease in the number of ribs, and abnormal development of the bones of the skull have been recognized in utero in the lateral view.



FIG. 10. Left transverse presentation, two weeks before term. Patient in labor for two hours. Strong pains, tearing in character, at frequent intervals. Membranes not ruptured. Roentgenogram shows fetus lying high above crests of ilium. Under deep anesthesia external cephalic version performed. Head held on brim of pelvis for nearly an hour. Pains practically ceased. Pituitin 0.2 c.c. given to strengthen pains and facilitate engagement. Patient delivered spontaneously of 6½ pound living baby.

early stage of labor where the correct diagnosis could not have been established clinically. Craniotomy was found to be necessary for the extraction of the fetus. The puerperium was normal. A mistaken diagnosis in this case would have endangered the mother's life. This case illustrates the great value of roentgenological diagnosis in cases of fetal abnormalities at or near term.

Roentgenology is also valuable in the differential diagnosis of obscure abdominal masses and pregnancy. Hydramnios is so commonly associated with monstrosities that a routine roentgenogram is necessary. Early recognition of these deformities

would prevent the continuation of such a pregnancy, a prolonged labor, or even cesarian section.

Hauch<sup>20</sup> has not found the x-rays of special value in the early diagnosis of pregnancy, as the diagnosis may be made equally early by other methods. But he has found it of definite value in differentiating between a pregnancy and a tumor; for the diagnosis of late extrauterine pregnancy; for demonstrating the presence of a dead fetus; for the diagnosis of twin pregnancy; and finally for the diagnosis of fetal malformations and monstrosities before or at the time of labor.

Favreau<sup>21</sup> states that in some cases the fetal skeleton is demonstrable in the roentgenogram before the fetal heart sounds can be heard. In 1 case at least, it was demonstrated before the fourth month. As a rule, however, he has found that the fetal skeleton cannot be demonstrated with certainty before the fourth month. In some cases a very careful examination of the roentgenogram must be made before evidence of the fetal skeleton is found. As a rule, in a five months' pregnancy, the vertebral column, slightly curved, and the base of the skull are visible, and in some cases the bones of the extremities.

The death of the fetus in utero is indicated by overlapping of the cranial bones and the disappearance of the cerebral contents. In case of maceration, the skeleton appears smaller than normal for the duration of the pregnancy and the outlines of the bones are somewhat obliterated.

Case<sup>22</sup> (1917) reported the first instance of roentgen diagnosis of anencephalus, before birth, and in 1926, he reported 3 additional cases. Other authors have reported 11 cases, making a total of 15. Roentgenological examination in anencephalus shows an absence of the fetal cranial vault, small orbits, absence of sella turcica, and a tendency to cervical spina bifida.

Two cases of anencephaly diagnosed by roentgenology are reported by Beath.<sup>23</sup>

The first patient, a primipara thirty-nine years of age, appeared to be in about the eighth month of her pregnancy. The roentgenogram showed a normally developed fetus as regards trunk and limbs, but no cranial shadow. Induction was decided upon and an anencephalic child weighing 5 lb. removed. The mother recovered. The second case was that of a primipara at full term. The roentgenogram showed fetal shadows of the thorax and limbs, but no cranial shadow. Before any measures could be taken the patient entered into labor, which lasted two days. Delivery was difficult and the mother died from shock. Beath thinks these 2 cases prove quite definitely the value of early roentgenology in doubtful abnormalities of pregnancy.

There is a syndrome which is strongly suggestive of deformed fetuses in utero (Falls<sup>24</sup>). Roentgenograms will clearly demonstrate the deformity in anencephalic, hydrocephalic or spina bifida fetuses as early as the sixth month; but a negative x-ray does not exclude the possibility of deformity. The syndrome is as follows:

1. Hydramnios occurring about the seventh month, associated with uterine tension and easy ballottement.

2. Inability definitely to outline the fetal head suggests anencephaly, while abnormal size or consistency suggests hydrocephalus.

3. Anencephaly is suggested by difficulty in differentiating between the fetal parts either by abdominal or vaginal palpation. Also a soft meningocele surrounded by a bony ring may be felt on vaginal examination with a finger inside the cervix in cephalic presentations.

4. Fetal heart tones heard faintly or absent when hydramnios is marked.

5. Abnormally active fetal movements, which may become convulsive if pressure is made on the head in cases of anencephalic monsters.

#### OVARIAN PREGNANCY

Ovarian pregnancy has been diagnosed by skiagrams (Candy<sup>25</sup>). The appearance

was that of normal pregnancy of about eight and one-half months, but the patient complained of great discomfort and distention. Palpation and vaginal examination under anesthesia failed to reveal the presenting part. X-ray examination showed a fully developed fetus, the position and attitude of which were extremely irregular. The head and cervical spine were acutely flexed upon the chest, the cervical spine forming an acute projection against the anterior abdominal wall of the mother. The head was outside the pelvis and could not be made to engage. The lateral view showed the fetus to lie in a much more ventral position than normal. Cesarean section was performed and a fulltime ovarian pregnancy revealed. The uterus was in the pelvis and was slightly enlarged. The right fallopian tube was flattened and stretched over the gestation sac. The tissue of the right ovary was thinned out and constituted the outer layer of the sac, which lay above the broad ligament. The child appeared to have been dead for two or three weeks.

Tubal pregnancy is apt to rupture before reaching a size permitting of its roentgenological recognition other than by the special method of uterosalpingography.

#### THE MECHANISM OF LABOR AS STUDIED BY X-RAYS

The older texts on obstetrics taught that, at the onset of labor, the fetus is forced towards the path of least resistance, i.e., the lower uterine segment and the cervical canal. In the mechanism of labor the passages are the determining factors. The different diameters of the pelvic planes and the varied measurements of the manifold circumferences of the fetal-presenting part necessitate the rotation, flexion, etc., of the fetus, in order that it may pass through the birth canal.

Recent studies have somewhat modified this teaching. The anterior rotation of the child is governed by the law of accommodation of elastic resistance to the shape of the container. The birth canal is shaped

like a straight tube with a sharp upward curve at its lower end; the fetus, like two ovoids, head and trunk, united by a hinge, the cervical vertebrae. The birth canal would, therefore, force such a bicorporate hinged object to bend in the same direction, i.e., the lower ovoid, or presenting part, would be forced upward or anteriorly. The fetus, due to uniform internal pressure, assumes a cylindrical contour, with a maximum bending facility in certain directions only: the head backwards and the body in a diametrically opposite plane. In order, therefore, for the fetus to pass the lower upward curve of the birth canal, it must proceed with a spiral-like motion so that it approaches the curved portion of the canal with that part of the fetal ovoid possessing the greatest bending facility in that direction.

Warnekros<sup>26</sup> was able to obtain roentgenograms of the fetus in all stages of labor; and he has shown definitely that, when the head of the fetus enters the pelvis, the occiput and sinciput are on the same level, in a position between flexion and extension. In the first stage of labor, the uterine contractions cause the fetus to assume a more pronounced attitude of flexion, which is, however, only transitory; between pains, the child assumes a more natural and comfortable attitude of semi-flexion. A reactive influence upon the fetus sets in with the rupture of the membranes, causing it to stretch out, so that the fundus uteri can be observed rising towards the ensiform process.

The spinal column is so constructed that each division tends to bend in the opposite direction of the other so that orthostatic posture is maintained. The force of the fetal axis pressure directed to the upper pole will cause the entire column to assume a form which will transmit this pressure to the lower pole. The dorsal vertebrae assume a kyphotic curve and the cervical vertebrae a compensatory lordotic curve. When the force of the uterine contraction is transmitted to the head, attached to the vertebral column at its condyles, the

sinciput is flexed and the occiput descends and is rotated anteriorly.

It has been further shown by Warnekros that the fetus is not an ovoid cylinder with bony protections consisting of the bones of the upper and lower extremities. The fetal extremities do not assume a regular attitude, but are thrown about in the uterus. The back of the fetus rotates anteriorly before the head rotates, and when the head is at the orifice, with the occiput pointing directly anteriorly, the shoulders are then entering the pelvis transversely. The chest of the fetus appears compressed while making its exit from the pelvic outlet.

Clinical x-ray studies concerning the mechanism of labor help to explain how puerperal fever may develop in the absence of infection introduced from without. They prove that the presenting part acts like a bacteria-smearing swab, whereby the damaged tissues with which it comes in contact may readily be inoculated by microorganisms already present in the vagina.

#### SUMMARY

Roentgenography has proved its value in obstetrics principally for the following diagnostic purposes:

1. For the positive diagnosis of pregnancy in obscure cases. This can be accomplished by the fourteenth week, sometimes earlier. In some of the author's cases, the clinical findings strongly suggested uterine fibromyomata and only the roentgenogram

saved the patient from an unnecessary hysterectomy.

2. For the recognition of twins. Particularly in obese patients, there may be difficulty in hearing two separate fetal hearts or palpating a multiplicity of fetal parts; vice versa, the same fetal heart may sometimes be heard clearly in widely separated locations, leading to an erroneous diagnosis of twin pregnancy. In such cases, roentgenography gives a definite answer.

3. For differentiation between pregnancy and tumors. Here roentgenography supplements findings by the Aschheim-Zondek test.

4. For diagnosis of tubal and ovarian pregnancy.

5. For revealing the presence of a fetal monster. The recognition of anencephalus and other forms of fetal monstrosity is greatly facilitated by x-ray study.

6. For giving information as to the presentation and position of the fetus. As shown by several of the author's films, the exact presentation and position are revealed with far greater accuracy than can be determined by physical examination alone. This also obviates the need of a pelvic examination.

7. For demonstrating the mechanism of labor.

8. For supplying a more accurate method of pelvimetry than any heretofore proposed and furnishing a means of cephalometry in utero. This subject will be discussed in a subsequent paper appearing in a future issue of THE AMERICAN JOURNAL OF SURGERY.

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[For remainder of References see p. 442.]

# PYELOGRAPHY WITH EMULSIFIED CAMPIODOL\*

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FOR the past eight years I have been trying various solutions for pyelography. I first used sodium bromide, with equal parts of acacia solution, and is marketed in ampoules containing 10 c.c. of the emulsion. I agree with Glaser and



FIG. 1.

FIG. 2.

FIG. 3.

FIGS. 1, 2, 3. Pyelogram in chronic pyelitis.

but found that it was not sufficiently opaque in less than 25 per cent strength, when it is somewhat irritating. Neosilvol, also, must be from 20 to 30 per cent, but it is relatively non-irritating and quite satisfactory. Sodium iodide, 12.5 per cent, is a satisfactory solution except that in about one-half of the patients it causes considerable pain for a few hours after its use. Furthermore, its presence in an inflamed pelvis causes pain, so that in my experience it is difficult to tell when the pelvis is full, and unsatisfactory pyelograms often result. Lipiodol diluted with olive oil is non-irritating and makes good ureterograms. Since it is not miscible with urine, the finer details of the calyces are not shown. In addition, the viscosity of lipiodol is so great that injection through a ureteral catheter is difficult.

Campiodol is a stable, non-toxic, iodized rape seed oil containing 43 per cent iodine. For pyelographic purposes it is emulsified

Kutzman,<sup>1,2</sup> who first used it in pyelography, that it is remarkably free from irritating properties.

The warmed emulsion can be injected easily through a No. 6 French catheter, and the patient has no discomfort until the pelvis is full. The injection should be stopped when the patient reports a feeling of fullness in the kidney region. There is no after-pain unless the pelvis has been overdistended.

Pyelograms made with emulsified campiodol are as clear as those obtained with 12.5 per cent sodium iodide, and ureterograms are better, as the increased viscosity delays the emptying time of the ureter. Accompanying illustrations demonstrate its value.

<sup>1</sup> Glaser, M. A., and Kutzmann, A. A. Emulsified campiodol as a pyelographic medium. *Ann. Surg.*, 270, 1929.

<sup>2</sup> Kutzmann, A. A. The use of emulsified campiodol in urography. *J. Urol.*, 22: 573, 1929.

\* Read before the North Central Branch of the American Urological Association at Indianapolis, October 23, 1930.

# WHOLE BLOOD TRANSFUSION\*

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**T**RANSFUSION of whole blood is conceded to be far more beneficial to the patient than the transfusion

these methods to excellent advantage but their rapid and exacting technique precludes their use by those who transfuse only occasionally instead of frequently.

The multiple syringe method of Lindeman and the syringe and valve methods of Unger, Soresi and others have been widely used by operators who prefer whole blood transfusions, but the simplest and most durable of all the transfusion pumps, which was designed by J. R. Head has not received the recognition it deserves. The elimination of valves, springs, and small orifices through which blood must be forced under pressure, contributes to the ease of operation and obviates fibrin formation and sticking. All metal construction renders it unbreakable and the cost of operation and upkeep is nil.

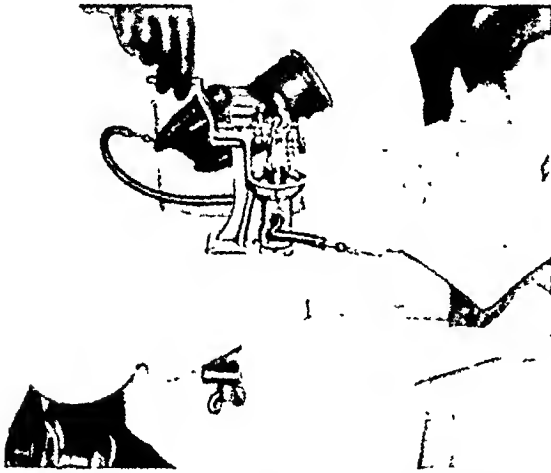


FIG. 1. Head transfusion pump in use. The donor's needle is held in proper position to prevent invagination of the vein wall into the tip of the needle by the strong pump suction.

of blood which has been chemically or mechanically altered to prevent coagulation.

The exacting technique of the earlier methods of whole blood transfusion presented so many difficulties that these methods have not become popular, while the citrate method has been widely adopted because of its simplicity of performance.

While the Kimpton-Brown paraffin lined tube causes the least mechanical damage to the blood of the several whole blood methods which allow measurement of the amount of blood transfused, it is necessary with this method to dissect out both the donor's and recipient's veins. This is, of course, an objectionable feature of the method. The Vincent and Moore tubes, with their large needles, obviate dissection of the veins in most cases, and are thus the most practical of the paraffin tube methods. A skillful technician can use

## TECHNIQUE

1. A healthy, Wassermann-negative donor of the same blood group as the patient, who has been properly cross-matched before transfusion, is used.

2. The pump, together with needles, a sharpening stone, rubber tubing, glass adaptors, a porcelain eup, an ampule of novocaine and a hyposyringe, gauze sponges, towels, gloves and gown are wrapped on a tray, autoclaved and the sterile pack kept ready for use at any time.

3. An armboard, 30 by 14 in., is placed under the donor's shoulders and comfortably padded. The donor's arm, with a sphygmomanometer bag for a tourniquet, is cleansed and laid on a sterile towel across the side of the armboard nearest the operator.

4. The pump is fastened to the armboard and the patient's arm is laid on the opposite side of the pump. Both arms are then covered with sterile towels, exposing the puncture sites only.

\* From the Surgical Section of the Jackson Clinic. Submitted for publication January 8, 1931.



5. The needles are "touched up" on the oil stone, if necessary, and attached to the pump by means of glass adaptors and heavy rubber tubing. The system is then filled with saline and the donor's needle left in the saline cup.

6. The recipient's veins are distended by tourniquet pressure and puncture is made with the attached needle through an intradermal novocaine wheal. Blood appears in the glass adaptor when the vein is entered. The needle is inserted well into the vein and tourniquet pressure released. A sufficient amount of saline is then pumped from the cup into the recipient's vein to assure the operator that his needle is properly placed.

7. The donor's vein is then punctured, the counter reading noted and the transfusion completed by pumping the required number of turns at the rate of about 100 turns a minute. The glass adaptors are con-

venient as venepuncture can be done without loss of blood or soiling of linen as when puncture is done with a detached needle.

8. The donor's needle is withdrawn first, dropped into the saline cup and pumping continued, washing the remaining blood into the patient's vein.

9. The entire procedure can be completed in seven to ten minutes with no loss of blood.

#### CONCLUSION

Personal experience with each of the transfusion methods mentioned, leads me to believe that the Head transfusion pump provides a very simple and safe method of whole blood transfusion which may be performed by anyone capable of accurate venepuncture.

In series of 200 transfusions with this pump, reaction has not occurred when a properly cross-matched donor was used.

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# MASSIVE PULMONARY COLLAPSE

## COMPLICATING PNEUMONIA\*

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**M**ASSIVE pulmonary collapse of the lung is a definite clinical entity and is a condition in which one or more lobes, previously well aerated, lose their air and collapse. In this collapsed state the lung occupies a smaller space than it did when fully expanded and becomes denser in character.

Pulmonary collapse or pulmonary atelectasis, whether it be postoperative or the result of a complication of other diseases, is to our mind the same as regards the etiological factor.

The literature contains abundant material of the postoperative type, but in reality the etiology is the same as was found in our cases following the onset of pneumonia.

Attention was first called to this condition by Pasteur in 1890, although an identical case was reported by Pearson Irvine in 1876. Later, J. Rose Bradford wrote on this topic, while recently great strides have been made by such geniuses as Jackson, Lee, Tucker, Clerf, Hearn, Mastics, Davidson, Harrington, Sante and others. We believe this condition exists more frequently than is thought. Many cases are mistaken for pneumonia for the signs and symptoms are identical in a great proportion of cases; when this happens the patient expires as an unrecognized case or the diagnosis is verified at autopsy.

*Types:* Several authors have classified massive collapse into clinical types:

Mastics:

- a. Fulminant or massive type.
- b. Moderate type.
- c. Late or mild type.
- d. Transient type.

Lee and Tucker suggest two groups:

- a. Massive.
- b. Partial.

These authors also use a strictly anatomic classification:

- a. Massive.
- b. Lobar.
- c. Lobular.

We believe that the latter classification is more consistent with the generally excepted nomenclature.

*Etiology:* There are still a number of causes suggested but no general acceptance of any of them. The one most accepted is the explanation of Elliott and Dingley that it results from diaphragmatic immobilization associated with bronchial obstruction, the alveolar air being absorbed by the circulating blood. Jackson, Lee and Tucker, in support of this theory, have removed masses of bronchial secretions obstructing the bronchus in 3 cases, Lee and Clerf in 2 cases, and Hearn and Clerf in 1 case. This theory is also supported at this clinic, as the author reports 2 similar cases. The tenacious secretion completely occludes the bronchi proximal to the collapsed tissue and upon aspiration the affected lung reinflates with air. On collecting this tough, tenacious material in a Luken's specimen tube, it is so thick and stringy that in a few minutes it becomes jelly-like in consistency. We feel that blocking of a bronchus with this thick secretion is a definite etiological factor in collapse. Everyone will admit that a lung cannot expand when the bronchus is completely blocked.

The mechanism by which the obstruction is produced was suggested by Archibald. Following the effort of coughing there is a more or less complete evacuation of the bronchial contents, but immediately following the expiratory effort of coughing there is a great, if not greater, inspiratory effort when probably as large

\* Submitted for publication October 16, 1930.

or a larger volume of air is drawn into the alveoli. The question was raised by Archibald whether, if the bronchial secretions

diaphragm of the affected side is elevated while the opposite side is lower than its normal position.



FIG. 1. Roentgenogram (taken by Dr. W. E. Reiley) three days after onset of pneumonia and one hour after symptoms of collapse appeared. Collapse of entire right lung.



FIG. 2. Roentgenogram by Dr. W. E. Reiley taken twenty-four hours after first bronchoscopic aspiration and twelve hours after appearance of collapse the second time. Collapse of entire right lung.

were not entirely expelled by the respiratory effort, they would be drawn further into the bronchial tree by the inspiratory rush of air.

**Signs and Symptoms:** The symptoms vary according to the part and amount of involvement. The patient may complain for hours before clinical symptoms appear in reality. A rise in temperature, increase in pulse rate and respirations constitute the starting point, followed by a cough with very little or no expectoration, pain in the chest, cyanosis and dyspnea. Inspection reveals immobility of the affected side and as a rule displacement of the apex beat toward the involved side, but this was not verified in one of our cases, for the beat was not displaced. The intercostal spaces are narrowed, the ribs seem to converge; dullness or flatness is present over the affected area while above hyperresonance and even tympany may be found. Pectoriloquy is often marked. The

**Treatment:** Bronchoscopic investigation should be carried out early after the diagnosis of collapse is made if the surgeon and internist deem it a capable procedure in the particular case. A skilled bronchoscopist can carry out the regular procedure with very little discomfort to the patient. General anesthesia is contraindicated. For adults morphine may be given for the cough, while in children over twelve years of age, cocaine may be applied locally to abolish the cough reflex.

**CASE 1.** C. McM., a male aged thirty, was admitted to the medical department of the Clearfield Hospital, complaining of pain in the chest, fever and difficult breathing. The history was that three days before he had had a severe chill which was followed by a rise in temperature associated with sweating. These symptoms continued to become markedly worse. He therefore applied for admission to the hospital.

On admission the temperature was 103°F.

pulse 120, respirations 30. The blood hemoglobin was 70 per cent, the erythrocytes numbered 3,380,000, leucocytes 5800, the polymor-

Dr. S. J. Waterworth saw the patient in consultation at this time, following which a diagnosis of possible collapse of the entire right



3-23-30

FIG. 3. C. McM. Roentgenogram by Dr. W. E. Reiley taken twelve hours after second bronchoscopic aspiration. Right lung almost clear except for mottling as appears in resolving pneumonia.



FIG. 4. C. McM. Roentgenogram by Dr. W. E. Reiley taken nineteen days after first bronchoscopic aspiration. Right lung shows some mottling with great improvement since last examination.

phonuclears 52 per cent, small lymphocytes 40, large lymphocytes 7, transitionals 1; urea-nitrogen 45.36 mg., creatinine 2.5 mg., sugar 80 mg. The Kahn test was negative. The renal efficiency test showed a total of 5 per cent.

*Physical examination* revealed the following: *Head*—scalp normal, eyes negative; mouth—tongue dry and coated, throat injected. *Chest*—expansion limited on the right side; impairment over the upper lobe of the right lung, many râles; pulse rapid, heart sounds weak, slight functional systolic murmur present. A diagnosis of lobar pneumonia was made by the medical chief, Dr. G. B. Yeane, after which the patient was placed on the routine treatment. The two days following his admission he gradually grew weaker, the temperature rose while the pulse became rapid and weak. The patient became restless and dyspneic. There was marked limitation of movement of the right chest. There was a hyperresonant note over the entire left lung area. The percussion note over the right lung was dull. The respiratory rate was 48.

lung was made. Roentgen examination was made with the following report: "The entire right chest is opaque, the ribs can be seen, opacity faintly, as also the right border of the heart. There may be a thickened pleura with a small amount of fluid. Since the left lung is not involved it is most probably not malignant."

After the consultation the patient was referred to the bronchoscopic department and three hours later bronchoscopy was performed with this report: "Mucous membrane of the posterior pharynx injected, the epiglottis flaccid and lying over the laryngeal opening. The mucous membrane of the larynx and ventricular bands very red. The glottic chink and vocal cords were normal. The mucous membrane of the trachea and right bronchus was of a deep red color." When the tip of the bronchoscope was passed into the right bronchus about 3 cm. below the earina it met an obstruction which had the appearance of a gelatinous material. The aspirating tube was passed through the bronchoscope to the obstructing area and after careful manipulation the tip of

the aspirating tube was teased through what seemed to be gelatinous material. After the tip passed 4.5 cm. through this substance aspiration took place with the result that a thick tenacious secretion in which was found small particles which in appearance resembled necrotic lung tissue. This material was aspirated into a Luken's specimen collector. The aspirating tube was then brought out and about 5 cm. above the tip there was a thick plug of gelatinous material adherent. Another aspirating tube was placed into the right bronchus until complete removal of the material which amounted to 18 c.c. was accomplished.

Instantly after the aspiration the dyspnea disappeared and movement of the right chest with respiration was noted. The patient stated that he could breathe without difficulty. A few minutes later faint breath sounds could be heard over the right lung area. The laboratory report from this specimen was as follows: "Thick mucopurulent material; pneumococci, few streptococci and staphylococci." That evening the temperature dropped from 103.2°F. to 98.4°F. with an associated decrease in the pulse and respiratory rate. The following morning the temperature rose to 103°F. with an increase in pulse and respiratory rates. The symptoms of restlessness and dyspnea again became marked. Roentgen examination gave the same appearance as on the preceding day. Here again it was decided to perform bronchoscopy aspiration, at which time 12 c.c. of thick purulent secretion were withdrawn by aspiration. The temperature dropped to normal as did the pulse and respiratory rates. Roentgen examination twelve hours after second bronchoscopy aspiration showed that the right lung was almost clear; there was considerable mottling, such as appears in a resolving pneumonia. Thirty-six hours after the second aspiration considerable bubbling was noted, similar to that noted in pulmonary edema. Although the temperature, pulse and respiratory rates were normal a third bronchoscopy was performed. At this aspiration 6 c.c. of a dirty, mucoid substance were removed. The patient made a splendid recovery and was discharged twenty-six days after the first bronchoscopy. Roentgen examination on the day of his discharge gave the following report: "Lung markings are still exaggerated but there is continued improvement." The physical examination of the chest revealed both sides practically normal.

CASE 11. W. D., a male aged forty-three, was admitted to the hospital with a fracture of the right leg, which he received while at work



FIG. 5. C. McM. Roentgenogram by Dr. W. E. Reiley taken on patient's discharge from hospital. Right lung almost clear.

by falling through a trestle, a distance of 12 ft. He also complained of a severe cold and bronchitis at that time. He was put to bed and following roentgen examination the limb was put up in extension. Physical examination revealed a rather poorly nourished male. Eyes, ears and nose were normal; throat markedly injected and red; there was some impairment present over the hilum areas; the heart was normal; abdomen normal. The temperature was 98.2°F., pulse rate 84, respiratory rate 20. On examination of the blood the hemoglobin was found to be 75 per cent, erythrocytes numbered 3,850,000, leucocytes 17,000, polymorphonuclears 85, small lymphocytes 10, large lymphocytes 4, transitionals 1. The urea-nitrogen 13.54 mg., creatinine 1.66 mg., sugar 100 mg. The patient's condition improved as the temperature, pulse and respiratory rates remained within normal limits for a period of four weeks. During this time he had a cough with considerable expectoration. Four weeks following admission he complained of a chill which was followed by a rise in temperature to 103.2°F., pulse 130, respiration 30.

Physical examination of the chest revealed

an area of consolidation about the size of a half dollar in the left lower base. The next morning he became very restless, dyspneic and cyanosed.

was twisted on itself and removed. As the sponge was brought out a large gelatinous plug was found to have adhered to it. The

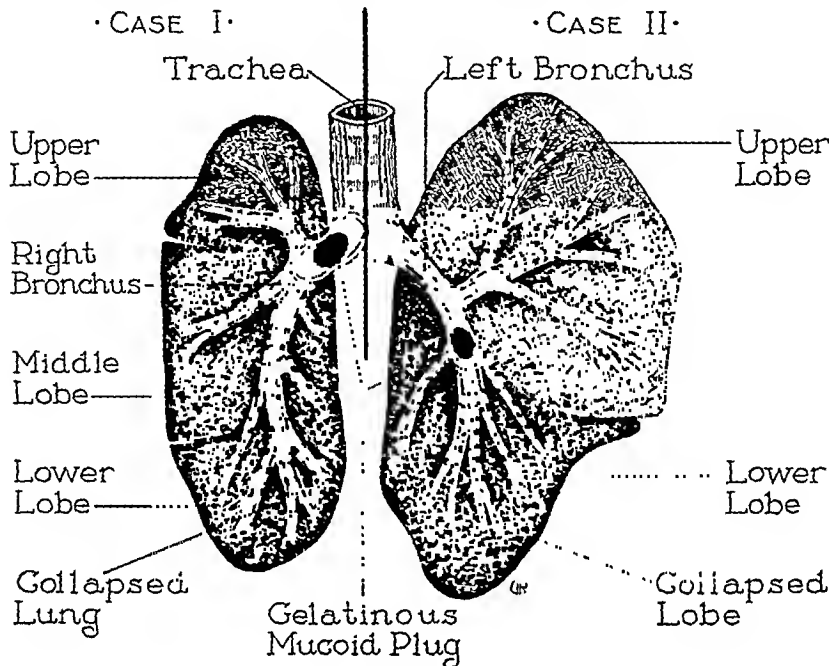


FIG. 6. Illustration showing mucoid plug and part of lung collapsed in each case.

The temperature rose to 104.2°F., pulse became more rapid and weak. There was marked limitation of movement of the left chest. The note over the upper half of the left lung was hyperresonant, while at the base over an area about the size of a small orange there was dullness outside of which the note was tympanic.

Roentgen-ray examination gave the following report: "Left inferior lobe very cloudy, upper lobe appears normal. The appearance suggests massive collapse. The heart is displaced toward the affected side." After consultation with the bronchoscopic department it was decided to do a bronchoscopic examination. One hour later bronchoscopy was done with the following report: mucous membrane of posterior pharynx dry and injected; glottic chink and vocal cords normal; mucous membrane of trachea and right bronchus was pale and rather dry. The bronchoscope was passed to the carina, thence into the left bronchus. About 3 cm. below the bifurcation an obstruction was seen that partially occluded the bronchus. The aspirator tube was put down to the obstructing area but nothing was obtained, as the substance was apparently too gelatinous. A sponge was then passed down the bronchoscope and as it reached the obstructed area it

aspirating tube was again put down to the left bronchus through which about 1 oz. of thick dirty material was aspirated into a modified Luken's aspirator. The patient immediately began breathing without difficulty and cyanosis disappeared. Movement of the left chest again occurred and several minutes later breath sounds could be heard over the left lung. The laboratory report of the specimen: "Thick mucopurulent material; many pneumococci and streptococci."

The following morning the temperature dropped to normal as did also the pulse and respiratory rates. Roentgen-ray examination sixteen hours after bronchoscopy gave the following report: "Appearance of left lung has improved, lower lobe not entirely clear." The patient remained in the hospital three weeks longer with no recurrence of symptoms.

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# BACILLUS FECALIS ALKALIGENES MENINGITIS\*

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CHICAGO, ILL.

**B**ECAUSE I have been unable to find anything in the literature about *B. fecalis alkaligenes meningitis* and as there is very little about other infections produced by this organism, I believe a report of the following case should be on record.

M. K., a boy thirteen years old, entered the Presbyterian Hospital, June 18, 1928. His chief complaints were: recurrent spasmodic contractions of the left side of his face, arm and leg, with headaches and dizziness occasionally followed by salivation and unconsciousness. When one and one-half years old, the patient fell from a porch receiving a severe blow on the head. He was in a hospital for one week and his doctor reported that he had skull fracture. Subsequently, a large hard lump developed. Except for an attack of rheumatism when he was six years old, the boy has been in good health. At the age of ten, he began to have headaches and later occasional twitching of the left side of his body. These would last for two or three minutes and occur two or three times a month. About two years ago, there occurred a period of freedom from attacks, lasting six months. For the past eighteen months, the attacks had increased in frequency and severity so that upon admission to the hospital, he was having several a week. A typical attack began with contractions of the muscles in the left side of the face and drawing the corner of the mouth outward. The left arm would then become rigid and finally the left leg. The average attack lasted about three minutes and, according to his mother, the patient was conscious during most of them. After an attack the patient complained of general weakness and he usually slept for fifteen to thirty minutes. A dull aching pain over the right eye would persist for fifteen to twenty hours. The boy's mother knew of no definite exciting cause for the attacks. Dizziness usually followed the attacks and occasionally nausea and vomiting. Strabismus has been present as far back as the mother can remem-

ber. His history was otherwise negative except for anesthesia of the right index and middle fingers following a lacerated wound of the wrist which occurred in April, 1928. The family history was negative for insanity or epilepsy.

On examination, there was a visible and palpable bony protuberance in the right parietal region measuring about 4 cm. in its transverse diameter. The left arm and hand were slightly smaller than the right but functioned normally. The arm measured from the tip of the acromion to the tip of the middle finger 2 cm. less than the right arm. The left arm was definitely weaker than the right. The left elbow and knee reflexes were slightly stronger than the right. Other reflexes were normal. Sensation was normal except for the anesthesia over the lateral half of the volar surface of the right hand excluding the thumb, evidently the result of recent injury. Ophthalmological examination was negative except for an alternating squint. X-ray films showed a definite thickening of the skull in the right parietal region with what appeared to be the remains of an old stellate fracture about 4 cm. from the midline in the neighborhood of the fissure of Rolando.

The diagnosis of Jacksonian epilepsy, probably the result of a depressed skull fracture, was made. Since the patient was right-handed and there seemed to be little danger of producing new symptoms by operation, an exploratory craniotomy over the right Rolandic area was done on June 28, 1928. An osteoplastic flap was turned down. Some difficulty was encountered owing to the depression and thickening of the bone in the region of the injury. The dura was adherent at this point and there were a number of irregular spurs of bone on the dural side of the flap. Although no undue bleeding had been encountered, the patient showed signs of shock and the operation was discontinued. On July 5, the patient having made an excellent operative recovery, the stitches were removed and the flap separated by blunt dissection. A very soft area was found in the anterior-superior portion of the wound beneath

\* From the Department of Surgery, Rush Medical College of the University of Chicago, and Presbyterian Hospital of Chicago. Submitted for publication October 9, 1930.



a thickened scarred dura. With an aspirating needle a brownish turbid fluid was withdrawn. The opening was widened and found to be a cyst about the size of an English walnut with a thin smooth lining. An opening was accidentally made through this exceedingly thin wall exposing the lateral ventricle and furnishing an excellent view of the foramen of Monro. A considerable amount of clear spinal fluid escaped. The dura posterior to the cystic area was firmly adherent to the brain. It was freed and removed for a distance of about 3 cm. The brain beneath this was whiter than the surrounding tissue. The irregularities on the inner surface of the bone flap were carefully removed and the flap replaced without an attempt to close the dural defect.

The following day, the patient began to run a septic temperature varying from 101° to 103°F. The scalp wound remained clean but the dressings were saturated with cerebrospinal fluid requiring daily change of dressings for about eight days. On July 16, eleven days after operation, the patient had a positive Kernig's sign. He began to vomit and his disks appeared slightly blurred. An unsuccessful attempt was made to reestablish drainage from the wound. The patient's condition remained practically the same except for a slight stiffness in the neck until July 19, when at Dr. Bassoe's suggestion, spinal puncture was made and 30 c.c. of turbid fluid were withdrawn. There was no marked increase in pressure. This fluid showed 4780 cells per c. mm. with both polymorphonuclear leucocytes and lymphocytes present; a positive Nonne and gold chloride, 0013321000. In smears, a gram negative short bacillus was found. This organism proved to have all the cultural characteristics of *B. fecalis alkaligenes*. The patient's temperature dropped immediately after the spinal puncture and stayed normal for the ten days he remained in the hospital. He had had a number of attacks preceding the spinal puncture and none afterward. The patient has now gone over six months without any recurrence of symptoms.

According to Stitt,<sup>1</sup> *B. fecalis alkaligenes* is a frequent inhabitant of the intestinal tract. It has been isolated in the blood in a few cases resembling typhoid fever. Fürth,<sup>2</sup> in 1913, reported 6 cases of typhoid-

like disease in which the *B. fecalis alkaligenes* was obtained and in which agglutination occurred for this organism, but not for typhoid or paratyphoid. The organism is usually considered non-pathogenic and Kendall<sup>3</sup> states that animal experimentation has been uniformly negative. As it culturally and clinically resembles paratyphoid, I looked over the literature on paratyphoid meningitis and found that in 1925, Bradhy,<sup>4</sup> reported the first case in English literature. He cited 7 others, the 1 reported by Walterhöfer<sup>5</sup> being of particular interest. This case occurred in a soldier of twenty, who received a rather minor cranial injury. Paratyphoid bacillus was obtained in pure culture from lumbar puncture with over 3000 leucocytes and lymphocytes in a turbid spinal fluid. Following the third spinal puncture, the patient's temperature dropped immediately to normal and he went on to a good recovery.

#### SUMMARY

This is the report of a case of Jacksonian epilepsy due to a traumatic brain cyst following skull fracture. *B. fecalis alkaligenes* meningitis followed operation. The patient made an uninterrupted recovery after spinal puncture. Attention is called to the similarity of the clinical picture with that of *B. paratyphosus*, *B. meningitis*. As far as I am aware, this is the first case of *B. fecalis alkaligenes* meningitis to be reported.

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# SURGICAL TREATMENT OF CARCINOMA OF THE THORACIC ESOPHAGUS

WITH REPORT OF A CASE\*

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IT is recognized by all engaged in the treatment of carcinoma of the thoracic esophagus that unless the growth is completely removed surgically the mortality is 100 per cent.

The difficulties which face the surgeon are many and very great: the inaccessibility of the organ; its anatomic relations and its anatomic structure; the absence especially of a serous coat and the poor blood supply which account for the frequency of necrosis and danger of postoperative infection of the neck, mediastinum, pleura and lung; the proximity of the vagi nerves; the presence of the diaphragm which prevents approach from below. Finally, it must be acknowledged that carcinoma of the esophagus is highly malignant and that the numerous operations devised are all followed by a fearfully high mortality, all of which taxes the courage of the surgeon.

These patients are in poor condition. Necessarily, the preoperative care is somewhat prolonged, and often the gastrostomy with forced feeding precedes by several weeks or months the final desperate attempt to remove the cancerous growth. In feeding by gastrostomy, milk, cream, sugar, orange juice, cod liver oil and stew made of meat, spinach and gravy will give a diet of protein, fats, carbohydrates, iron and vitamins. Even with the slight gain in weight which is always aimed at prior to the thoracic operation, the patient is a poor surgical risk. The problem, then, is to subject a poor surgical risk to a stupendous operation.

It was in 1738 that Goursald performed the first operation on the esophagus. He removed a foreign body from the cervical portion, the part of the organ easiest to

approach. It was not until 1888, 150 years later, that Nasiloff devised his mediastinal approach on the cadaver which was modified by Bryant in 1895 to the quadrilateral flap. Only thirty-two years ago, in 1898, Rehn first attempted the removal of a carcinoma of the thoracic esophagus in the living human. Since that time, the following methods of procedure, among others, have been devised in the effort to deal more safely with this disease.

1. The extrapleural dorsal approach with endeavors to reconstruct the lumen by suture end-to-end (or esophagogastrostomy).

2. Transpleural approach under differential pressure with attempts to restore the tube with or without transposition of the stomach by suture, buttons, or other methods.

3. Transpleural removal of the whole esophagus, placing the stump outside from an incision in the neck, and later reconstruction of the esophagus by plastic operation.

4. Extrapleural removal through invagination of the entire esophagus by combined method from abdomen and neck.

5. Extrapleural removal by a combined method from the abdomen and neck, or abdomen back and neck, with transposition of the stomach into the posterior mediastinum.

6. Dorsal approach and plastic repair by fascial transplants or grafts.

Some of these operations will result in strictures, and, because of poor blood supply, in sloughing or necrosis. Of the operations performed, the only intrathoracic procedures which have proved successful are those of Torek, Lilienthal

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and Eggers, the last of whom has had two successes.

In the selection of a surgical procedure, it would be unwise to choose a method which seems less radical if, by so doing, one offers to the patient an impracticable operation. The one operation which has proved most successful is that of Torek. Of approximately fifty known efforts and of four successful operations, Torek's method has been successful three times. If one includes carcinoma of the cardiac end of the stomach, other operations utilizing the same approach have been successful. The advantages of this operation are that it gives a wide exposure of the thorax, as the entire length of the esophagus lies in view. Any bleeding may be stopped at once. The lymphatics of the mediastinum are under inspection and a most extensive resection may be made with the least trauma and the most accurate observation.

The selection of anesthesia is very important. Sodium amytal or preliminary narcosis is beneficial, as it reduces the amounts of other anesthetic agents required. Pressure anesthesia is not absolutely necessary but it is wise to have it handy in case of need. Eggers states that inflating the lung frequently during the operation is effective in preventing pneumonia, and the lungs should be inflated without failure at the end of the operation, when the closure is attended by obliteration of the pleural cavity through adhesions of the lung to the thoracic wall. We believe that injecting the nerve supply of the field with novocaine, while sometimes of too short duration for the operation, will reduce the shock incident to opening the thorax. Novocaine with gas is ideal, while ether may be used if necessary. Ethylene may be equally good; in the minds of some, superior. Spinal anesthesia in its present development is not the safest type of anesthesia for the thoracic surgeon. The influence of the anesthetic on the postoperative recovery is profound.

#### CASE REPORT

A married woman, fifty-eight years old, with a history of previous excellent health was admitted to the New Asbury Hospital, February 15, 1930. Since August, 1929, she had been unable to swallow solid foods and upon admission was unable to swallow liquids. She had gradually lost weight from 189 to 108 lb. Some of the eye signs of hyperthyroidism were present, but the basal metabolism was plus eight. X-ray of the esophagus showed complete obstruction at the level of the tenth thoracic vertebra. The aorta was apparently normal. The following day, a Janeway gastrostomy was performed and a careful search made for metastases in the liver and lymphatics of the lesser curvature of the stomach.

On February 23, the patient weighed 120 lb., having made a gain chiefly through increase in fluid intake. On that day Dr. J. A. Myers injected 400 c.c. of air into the left pleural cavity; on February 24, 300 c.c., and on February 26, 500 c.c., at which time there was complete collapse of the left lung and positive pressure in the left pleural cavity of 0 to 3 atmospheres. On February 27, the thoracic operation was undertaken.

After inducing narcosis with a No. 1 H.M.C. hypodermic at 6:30 A.M. and a No. 2 at 7:30, at 8:00 A.M. novocaine blocking was performed of the left brachial plexus and the right eighth, seventh, sixth, fifth and fourth ribs. The incision started at the midclavicular line extending posteriorly through the seventh intercostal space to the tubular of the rib (paravertebral line) and upward through the seventh, sixth, fifth, and fourth ribs. The intercostal vessels on both sides were ligated and the pleura opened throughout the extent of this incision. This was accomplished under local anesthesia, but when attempt was made to manipulate within the chest, the respiratory reaction was so marked that the patient was placed under nitrous oxide. This was given without pressure. Rubber sheets were placed over the parietal and visceral pleura and the aorta and heart identified. Between these two structures an incision was made into the pleura posterior to the hilus of the lung which was carried from the diaphragm to the lower part of the arch of the aorta. Through this opening, the esophagus was recognized and felt to be a solid, hard, fusiform mass. The left vagus was observed at its upper end,

but was found to be involved in the carcinoma and later in the dissection had to be sacrificed 2 cm. above the diaphragm. The esophagus was easily liberated from the surrounding tissues and was divided from the stomach at the level of the diaphragm. This section was made by cautery between two ligatures. The lower end was inverted by a purse-string, which again was reinverted. The ligature on the upper stump slipped off and left exposed an area of carcinoma about the size of a dollar. This was covered by a rubber glove and ligated. In the subsequent dissection, the glove slipped off and another glove was applied and two ligatures placed. Section was made of the pleura above the arch of the aorta, the esophagus separated from its surroundings, care being taken to stay close to the organ, and not to injure the thoracic duct.

The dissection under the arch of the aorta and bifurcation of the trachea was most delicate. This was made from below upward, and from behind forward on each side loosening the branches of the vagus nerves without injury to the fibers passing to the pulmonary and cardiac plexuses. The esophagus was thus freed throughout its entire extent, but the mass was too large to draw under the arch of the aorta, especially since it must remain covered by the glove. So it was again sectioned between two ligatures above the tumor just below the arch of the aorta. The upper stump was drawn out above, through an incision in the neck just above the sternum, using blunt dissection and keeping close to the trachea to avoid the recurrent laryngeal nerve. There was just enough esophagus to reach the skin surface. One drain was passed through this opening into the posterior mediastinum. The pleura was closed using No. 00 plain catgut, and the ribs were brought into approximation with chromic No. 2. The muscles were closed from below upward: the anterior serratus, latissimus dorsi, trapezius, rhomboideus major, lower portion of the posterior superior serratus. Then the fat was closed with No. 1 plain Catgut and the skin with dermal.

The patient's pulse did not vary during the operation, and the only reaction she seemed to have was a respiratory one from manipulation. Postoperatively, morphine and fluids intravenously and under the skin were given. The second day, forty-eight hours after the operation, the patient was in excellent condition and she was allowed to wash the esophagus

through with drinks of various sorts. On the afternoon of that day she suddenly collapsed, and expressed the desire to die, which she did the following (third postoperative) day.

Autopsy showed the stomach sutured in the anterior abdominal wall, the opening in the anterior wall near the greater curvature. The curvatures were intact and there was no sloughing. There was no peritonitis. The diaphragm was at the fourth rib on the right and the fourth interspace on the left. The left lung was completely collapsed and firmly adherent to the posterior wall. There was a marked fibrinopurulent exudate over the entire left chest and the collapsed lung, and a foul smelling greenish exudate. On the right, the pleura was normal. The pericardial sac was normal with a normal amount of fluid. The left lung weighed 250 gm. It was adherent to the pericardium and to the chest wall posteriorly. On section it was deep red and fleshy; a small amount of fluid and blood was expressed, but no pus. The right lung weighed 500 gm. Crepitation was present throughout but reduced in the base. No nodular areas could be felt. On section, blood and fluid were present but no pus was demonstrated. The liver, heart, spleen and kidneys were normal. The esophagus was entirely absent. The stomach sutures where the esophagus was removed had held. There were no enlarged nodes near the stomach or in the mesentery, cervical or clavicular regions. In the region of the anterior mediastinum the tissues were necrotic and covered with foul smelling purulent exudate, thick and greenish yellow, near the point of attachment of the esophagus to the skin of the neck. No evidence of carcinoma could be demonstrated anywhere.

There were four sources of exposure to infection in this patient: (1) Section below the tumor with slip of the ligature; (2) section above the tumor; (3) cut end of esophagus on the skin surface with the drain leading to the mediastinum; (4) drinking of fluids forty-eight hours after the operation.

This operation is a feasible one for carcinoma of the thoracic portion of the esophagus. There is no doubt but that it is an heroic measure. Broders and Vinson have classified these carcinomas as 90 per cent in grades 3 and 4. This seems to be corroborated clinically. Of those patients

who do not die at or shortly after the operation, very few survive more than fifteen to sixteen months. It must be noted, though, that the cause of death is recurrence, not metastases. Torek's patient was living eleven and one-half years after operation.

It is only thirty-two years since the first attempt was made to offer surgical relief for carcinoma of the thoracic esophagus. In that time, many observations have been recorded making more certain a definite progress in success of treatment for this condition.

There are three suggestions to be offered from a study of this case, which may be considered contributions to the successful management of surgical treatment for carcinoma of the esophagus.

1. Preliminary artificial (closed) pneumothorax will allow rapid opening of the entire thorax without danger of shock. While artificial pneumothorax has been used in other types of thoracic surgery, it has not previously been recommended for esophagectomy. This removes one of the causes of death and is vital if the best results are to be obtained. There is little danger with this procedure and following closure, the air must be removed from the pleural cavity to allow the lung to expand. In the case reported, the air was not removed postoperatively, and this fact may have had some part in the death of the patient. There may be certain objections to this procedure, the feeling that the preliminary reduction of vital capacity may reduce the strength of the patient. The inflation of the lungs, as recommended by Eggers to prevent pneumonia, may still be conducted. The chief purpose of the pneumothorax is to permit rapid opening of the thorax with less danger to the patient.

2. Ligatures should be placed on the esophagus below the tumor, from above downward. The ligature on the upper stump is left long as a tractor in handling as it passes through the neck.

3. After the stump of the esophagus has

been brought through the skin at the suprasternal notch, the cancer may be removed below a ligature which should not be removed, but allowed to remain closed for a period of at least three days to allow healing; and better seven days. This removes one great cause of infection through mediastinal leakage. Eggers considers this of less value than the preliminary artificial pneumothorax. If these three procedures are utilized together with the technique already advanced, a definite decrease in operative and postoperative mortality will result. They will also shorten the operation by allowing rapid opening and more rapid dissection. The only possible danger of infection under these circumstances would be a rupture of the esophagus.

There are six recognized causes of death:

1. Shock from opening the thorax. This may be avoided by preliminary closed pneumothorax.

2. Surgical shock. This usually results from bleeding and exposure, and may be avoided by preliminary narcosis with some barbituric acid compound and hemostasis. Keeping the room warm and free from draughts will aid greatly, as will also the rapid removal of the cancer facilitated by preliminary pneumothorax.

3. The dissection itself. The vagi nerves are unquestionably the most important structure encountered. Sauerbruch expressed the view that removal of the thoracic esophagus is impracticable because of the danger of injury to the vagus nerves. The greatest care is needed during the liberation of the esophagus from under the arch of the aorta and the bifurcation of the trachea. Study of the anatomy of the vagi gives a clue as to how to proceed. If the nerves are dealt with separately and dissected from behind forward, there is least likelihood of injuring the fibers passing to the cardiac and pulmonary plexuses. If the nerves must be cut at any level, it should be as low as possible and done by sharp dissection. The nerves should not be cut above the fifth thoracic vertebra.

One should have at hand emergency stimulants such as coramine and adrenalin. The great danger arises from disturbance of the cardiac or respiratory fibers in their respective plexuses. The vagi nerves above the arch of the aorta are somewhat farther from the esophagus and not likely to be harmed with any degree of care during the dissection. The recurrent laryngeal nerve is also present but not liable to injury. The thoracic duct may be injured in the superior mediastinum. By adhering to the esophagus, one is fairly safe. Injury to the thoracic duct may render infection more probable.

4. Infection is the most serious of all complications and will follow the operation if there is any possible excuse for it. Willy Meyer states that only good fortune permitted Torek to close his successful case without drainage. Eggers drained both of his cases. Infection of the mediastinum and pleura, from opening the esophagus within the thorax, is the most obvious danger. The effort has been made to open the mediastinum extrapleurally to avoid pleural contamination. However, this makes the surgical technique so much more difficult that the question may logically be raised as to the superiority of the extrapleural method. The greater success of the transpleural technique is further evidence against the advisability of the extrapleural approach. Eggers and his co-workers, after further experience with the pleural stripping operation, question the superiority of this method over the transpleural Torek operation. To avoid infection, technical perfection is requisite with careful placement of ligatures, at no time allowing the open esophagus to expose its contents to the pleura or mediastinum. During the thoracic operation protection of the pleura from exposure and friction may be exercised by placing rubber over the parietal and visceral pleurae. The possibility of infection of the mediastinum and pleura is also decreased by leaving the stump closed until complete healing has occurred at the neck.

If these points are observed, it is not necessary to drain, as there is no exposure to infection granting that the surgeon has been careful in his technique. When drainage is used, it is best placed in the thoracic cavity below the sixth rib in the posterior axillary line. The barrel shape of the thorax makes this the most dependent part of the pleural sac. Any air left in the thorax after the operation should be removed by negative pressure. Eggers has made it a point to x-ray his cases in order to observe the presence of fluid. His study shows that the visceral pleural becomes adherent to the parietal very quickly after closure.

5. Infection of the lung: pneumonia. To prevent aspiration pneumonia, the esophagus should be emptied at the start of the operation. It may be advisable to leave a tube in the esophagus during the entire operation. If emptied at the start, it does not usually fill under the anesthesia. The selection of anesthesia is vital, and rapid dissection to reduce the amount of anesthesia needed. Preliminary narcosis and opening under local anesthesia will also decrease the total inhalation anesthesia. Eggers recommends inflation of the lungs at frequent intervals as a fine preventive of postoperative pneumonia. This was not done at our operation, but should be accomplished in every case at the close of the operation. Removal of the air by negative pressure, allowing the lung to expand following operation, may serve as well as positive pressure. Tight strapping of the dressings prevents too much motion with its injury to the lungs from the severed ribs.

6. Recurrence of carcinoma. Very rarely does carcinoma of the esophagus metastasize, probably because of the poor blood supply and its loose relations with other thoracic organs. The earlier the carcinoma is diagnosed, the more possible is its complete removal. By bringing the patient to the table in the best possible condition and by being radical in removal of the carcinoma, the more hopeful is the outlook.

Rapid progress has been made in this

field, considering the few operations performed. Although it has been attended previously by high mortality, improvement in technique will markedly decrease this. In view of the absolute certainty of death from this disease without operation, surgical removal should be attempted in every case where there is no evidence of metastasis.

## SUMMARY

At preliminary operation, a Janeway or Witzel gastrostomy is performed under local anesthesia and the liver and lymphatics in the region of the diaphragmatic esophagus are inspected. Two to six weeks being allowed for recovery and upbuilding of the patient, artificial pneumothorax is induced, the thorax is opened under narcosis and local anesthesia, using gas in addition if needed. Protecting the pleura with rubber sheets, the esophagus is dissected from its mediastinal bed and drawn out through the neck. Infinite care is taken to control hemostasis and protect the vagi nerves, consistent with complete removal of the carcinoma. Finally, all the air is removed from the thorax, the

chest is tightly strapped, and healing allowed for seven days before the stump of the esophagus in the neck is opened. The patient may then be allowed to drink.

Postoperatively and preoperatively, the scientific use of the gastrostomy, and the administration of fluids by vein and subcutaneously will give these patients the most hopeful outlook from surgical treatment of carcinoma of the esophagus. Only by prompt diagnosis and early treatment will it be possible to offer these patients anything but a 100 per cent fatal prognosis.

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\* Continued from p. 426.

# POSTOPERATIVE MASSIVE COLLAPSE OF THE LUNG

## REPORT OF A CASE\*

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**P**ULMONARY complications are among the most important post-operative problems. According to Scott about 3 per cent of all patients operated on, develop some type of pulmonary complication and one of every 200 operations results fatally from this cause. Notwithstanding the great interest in post-operative pulmonary complications there is a special group classified as massive collapse of the lung which has received slight attention. This condition presents itself as a definite clinical entity which in most instances escapes recognition. A description of this syndrome is found only in the "Oxford Medicine." None of the textbooks on surgery, gynecology, obstetrics, or postoperative care, mention it. Choyce and Keen briefly refer to it as a complication of gunshot wounds. Furthermore the etiology is not definitely accepted as proved although several brilliant papers have been written in an attempt to prove several widely different theories. Attention was first directed to it as a postoperative disturbance about 1908. The first case appeared in the American literature only as recently as 1922.

In 1854 Gairdner spoke of it as pseudo-pneumonic condensation of the lung. Pasteur characterized it as a total deflation of a large area of lung tissue of sudden onset due to failure of inspiratory power and attended by definite symptoms and physical signs. Scott in order to avoid confusion arising from the use of the word collapse, proposes the term active collapse to distinguish it from passive collapse which is due to compression. Coryllos and Birnbaum suggest as most appropriate obstructive massive apneumotosis of the lung. They believe there are only two kinds of collapse, acute, due to obstruction of a bronchus, and passive, from compression of a lung, e.g., pneumothorax.

The first description was given by Legendre and Bailly in 1844. They regarded it as a frequent complication of bronchitis in children and separated it from the inflammatory consolidations of the lung with which it was formerly confounded. Its cause is "partly the imperfect respiratory movements, and partly the obstruction of the bronchi with secretions. As air does not enter the lungs the alveoli collapse because of the elasticity of the lung parenchyma." Mendelssohn in 1844 produced atelectasis by obstructing bronchi with shot paper and gum arabic solution.

In 1846 Traube showed that artificial occlusion of a bronchial tube produced atelectasis of the corresponding portion of the lung and that the same phenomenon occurs when the thoracic cavity is opened. Gairdner in 1851 regarded obstruction of the bronchi with mucus as the most frequent cause of collapse. Barthels in 1860 first demonstrated mucous secretion in the bronchi corresponding to the atelectatic portion of the lung and later to the atelectasis of the bases following diphtheria. In 1879 Lichtheim obstructed bronchi with sticks of laminaria and produced collapse with absorption of the alveolar air by the circulating blood. He also established the speed of absorption of the different gases. Pasteur gave a new impetus to the study of this question. In a series of articles appearing between 1890 and 1914 he drew attention to the coincidence of collapse of the lung with paralysis of the diaphragm which he concluded was the principal factor in its production. Briscoe after an elaborate series of experiments concluded that massive collapse was the natural sequence of prolonged quiet breathing in the supine position in such people as do not use their abdominal muscles to fix their chests. Bradford in 1920 reported a case of contralateral collapse in a soldier

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with a superficial gunshot wound of the chest.

Chevalier Jackson and his associates have gone a long way towards clearing up the etiology of this perplexing syndrome. Their conclusions seem to corroborate the results of Caryllo's and Birnbaum's experiments carried out in the laboratories of Cornell Medical School. The latter have reported the results of a series of experiments on 56 dogs. Their results seem to make bronchial occlusion a primary cause and all other mentioned causes merely contributory factors. Lemon, in a recent paper, stated that he sectioned one or both phrenic nerves and did not find atelectasis either during life or at autopsy. This contradicts the conclusions of Pasteur.

Massive collapse of the lung is an unusual condition in which the lung without the presence of any gross lesion such as a bronchial obstruction, pleural effusion, etc., interfering with the free entry of air, becomes airless to a greater or less degree and therefore useless for respiratory purposes. It involves varying amounts of the lung in different cases, usually an entire lobe or the whole of one lung. Symptoms may be present or absent. Massive collapse is only seen as a complication of disease, injury or operation, is often overlooked and the signs found attributed to other causes. It is most often seen after abdominal operations. Impairment of the movements of the diaphragm may be a cause; prolonged anesthesia may induce the retention of secretions in the bronchial tubes and thus lead to its mechanical production. It has also been observed in cases where no anesthetic has been given. Non-penetrating wounds limited to the abdominal wall may also produce it and it is occasionally seen as a complication of wounds of the buttocks, pelvis, and thighs.

The most important physical sign is displacement of the cardiac impulse to the affected side. It may be found on the left in the axillary line and in right-sided involvement as far over as the nipple line. The impulse may also be displaced upward

as far as the third rib. The affected side is retracted and immobile. The diaphragm of the collapsed side is displaced upward and immobile. Roentgenologic findings have confirmed this (Sante). The percussion is impaired. Dullness marked in amount may be present up to the level of the clavicle. Two groups of cases may be recognized: one with diminished or absent tactile fremitus and breath sounds, and one with increased tactile fremitus together with tubular or amphoric breathing and with bronchophony and pectoriloquy. In both cases extreme displacement of the heart is present. The majority of the cases conform to the type with increased tactile fremitus and tubular breathing. The signs are apt to change in one and the same case; thus at first weak or absent breath sounds may be present, and twenty-four hours later these are replaced by loud tubular or amphoric breathing, with increased tactile fremitus. Sometimes a change takes place so that tubular breathing is replaced by weak or absent breath sounds and such alterations may take place more than once in the clinical course of the case. These repeated alterations are evidently dependent upon variations in the patency of the bronchial tubes. The symptoms vary in severity in different cases, and on the whole tend to be most marked at the onset of the condition. It is important to remember that massive collapse may involve the whole of one lung without the presence of any urgent symptoms, and the condition may be overlooked unless the chest is carefully examined. Scott found 10 per cent of his collected cases had no symptoms. Dyspnea is the most constant symptom in massive collapse; it is sometimes comparable to that seen in pulmonary embolism. Pain in the chest, cough, mucopurulent expectoration, and cyanosis are usually present. The termination takes place either by lysis or crisis. The presence of infected emboli in the involved area may cause infarcts with a resultant bronchopneumonia. The latter generally terminates



fatally. Lee believes that over 70 per cent of all postoperative complications are some variety of massive collapse.

Treatment is mostly symptomatic. If mucus is present aspiration through a bronchoscope is most effective.

Caryllos and Birnbaum have collected 118 cases from the literature with 30 deaths. Jackson and Lee reported a cesarean section in a woman eighteen years old with a sudden pulmonary complication appearing on the third day. Death occurred in six hours. Partial collapse of the right and left lungs at the base, local peritonitis, paralytic ileus, hydronephrosis, and thick mucus in the left lower bronchus were found at autopsy.

Bergamini and Shepard reported a case of a woman sixty-nine years old on whom a laparotomy was performed. Exodus took place at the end of the operation. The autopsy revealed a massive collapse of both lungs.

These are the only cases I could find in the literature which are in any way similar to the case reported here.

My case report deals with a primiparous negress twenty-four years old. The family and previous personal history had no relation to the obstetrical problem which was presented during the first stage of labor. There were no subjective or objective evidences of disease present at the physical examination. Blood pressure was 98/54. The patient was admitted to the hospital having pains every five minutes. Her pains had commenced eight days previous to admission.

The cervix was 5 cm. dilated, with cephalic presentation, and the caput protruding well into the cervical canal. The head was unengaged. Abdominally a well marked contraction ring was easily palpable 7 cm. above the symphysis. The lower uterine segment was very thin and the right lower quadrant of the abdomen was exquisitely tender, suggesting possible rupture. The fetal heart was 140.

Low cesarean section was decided upon and successfully carried out, with the use of the Beck technique, and a living male was delivered. The time of the operation was forty-five minutes.

At six P.M. the same evening the pulse was 130, and a large blood clot appeared at the

vulva. At midnight the temperature was 101.6°F., respirations 38, pulse 136. During the night the patient became dyspneic, with an apical pulse of 160. She was restless and tossed about constantly.

At 7.30 A.M. next morning the radial pulse was scarcely perceptible; apical pulse was 160 and weak; dyspnea had increased and she complained of pain in the chest. Temperature was 102°F., pulse 160, respirations 45. Preparations were made for a blood transfusion but excitus took place at 7.55 A.M. The probable cause of death at this time was internal hemorrhage and pulmonary embolus.

*Autopsy findings were as follows:* Heart: pericardium negative, right auricle and ventricle markedly dilated containing red clots, myocardium paler than normal with cloudy swelling.

Lungs: Massive collapse of both lungs: bases of both lungs at level of fourth. Right lung weighs 300 gm.; left lung 250 gm. The diaphragm was at the level of the fourth rib on both sides. Right lower lobe showed five recent infarcts (red). No evidence of pulmonary embolism. Pleural cavity negative. No evidence of obstruction in the bronchi or bronchioles. Microscopic section showed areas of collapse with other areas of normal alveoli.

Uterus: No evidence of hemorrhage or infection along the line of the incision. The organ was globular, firm, and contracted. Cavity contained few dark red clots and small segment of placental tissue.

Spleen: A few red infarcts were present. All the other organs were normal. Cause of death: massive collapse of the lungs.

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# TRAUMATIC RUPTURE OF THE CORPORA CAVERNOSA

REPORT OF A CASE\*

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ATLANTA, GA.

**T**RAUMATIC rupture of the penis, also designated by the obsolete term "fracture of the penis," although a rare clinical entity occasionally does occur. The lesion consists chiefly of a tear in the fibrous sheath of the corpora cavernosa. The condition always occurs during erection and is usually due to a sudden rough bending of the penis downward toward the thighs. It may result from a direct blow. In some cases the corpora with their sheaths are weakened as a result of some previous disease and are therefore more susceptible to rupture.

When rupture occurs, there is a sudden pain at the site of injury associated with a crackling sound. The penis soon begins to swell due to the escape of blood into the subcutaneous tissues and reaches an immense size. The pain soon subsides and there is a feeling of fullness. The penis is bent toward the uninjured side. The ecchymosis gradually disappears, but a scar may result which may interfere with coitus. Suppuration due to a broken-down blood clot may occur.

Before presenting this case, I would like to refresh your minds with the anatomy of the penis, by reviewing briefly some of the anatomical factors involved. The main portion is made up of three elastic bodies, separated from each other by envelopes of strong, fibrous tissue. The two corpora cavernosa which lie side by side, occupy the dorsal position and comprise fully two-thirds of the organ. In the angle formed by their apposition, is the corpus spongiosum through which passes the urethra.

The corpora cavernosa are widely separated behind but are in close contact in the major portion of the organ. They arise on each side from the ascending ramus of the ischium, converge rapidly and meet just in front of the arch of the symphysis pubis.

The corpora cavernosa are invested by a dense fibro-elastic sheath, or tunica albuginea which is rather tough and strong. It consists of two layers, an outer layer of longitudinal fibers and an inner layer of circular fibers. The inner layer of the tunica gives off numerous fibrous septa, which anastomose freely to form irregular spaces or areolae. They contain connective tissue, elastic and unstriated muscle fibers, and form the supporting framework for the blood vessels.

The corpus spongiosum, which is composed of erectile tissue, is subdivided into bulb, body and glans. In addition to the sheath which envelopes the corpora cavernosa and spongiosum, external to these is another sheath which binds all the structures together and is known as Buck's fascia or fascia penis. The two rounded extremities of the corpora cavernosa are completely invested by this covering which is attached firmly to the base of the glans, and at the angle of the penis where it joins the suspensory ligament above and the deep layer of the superficial fascia below. It will be noted that the arteries of the penis supplying the erectile tissue and the envelopes, are all branches of the internal pudic, except the small external pudic branches of the common iliac, which supply blood to the envelopes only.

J. G., aged thirty, white, single, a jeweler by profession, appeared at my office September 23, 1929, in a very much excited condition. His face was pale, the skin bathed in a cold perspiration, pulse was fast but regular, and he appeared worried. He was given some aromatic spirits of ammonia and in a few moments stated that he felt much better. He then began with the following narrative, which he in all sincerity swears is the truth. About one-half hour previous to his visit to my office, he stated that he felt a desire to move his bowels and

\* Presented at a meeting of the Fulton County Medical Society, October 2, 1930.

went to the toilet. He assumed his usual posture on the toilet seat and during the act, tried to force his penis, which was fully erect at the time, downward into the bowl. Suddenly, he felt a crackling sensation in the shaft of his penis and there was a sudden severe pain at the point of injury. He became very much frightened and watched anxiously for developments. The entire penis soon became swollen and edematous, and assumed a bluish-reddish discoloration which also extended to the entire scrotum and inner surfaces of the thighs.

Physical examination, which was limited to the genitourinary tract, revealed the following findings. The penis was enormously swollen and slightly bent toward the right. The entire organ showed a bluish-red discoloration, which extended toward the scrotum and inner surfaces of the thighs, due unquestionably to the escape of blood throughout the subcutaneous tissues. The patient had difficulty in urinating. Because of the edema and swelling, it was rather difficult to palpate the organ and it was deemed advisable to put the patient in bed and observe him closely. However, I at first satisfied myself that the urethra was intact, as a small catheter entered the bladder without encountering any obstruction and there was no sign of urinary extravasation. The penis was elevated and cold compresses continuously applied. Morphine sulphate grains  $\frac{1}{6}$ , and atropine grains  $\frac{1}{150}$  were given. The swelling and ecchymosis persisted for about eight days and slowly began to subside. The patient remained in bed during all this time and then reported to the office. Some discoloration was still present but the penis had almost assumed its normal size. Upon palpation of the organ I could distinctly feel on the left side of the penile shaft a small hard, fibrous structure, evidently a scar resulting from the rupture. This did not cause the patient any pain unless the penis became erect. In the meantime he was seen daily and diathermy treatments applied for the purpose of softening the fibrous scar, which responded very well. During the course of the treatments, he was also observed by Dr. Omar Elder, the latter advising treatments to be continued along the same lines as were being pursued. On October 15, an abscess which developed upon the dorsum of the penis, due to a broken-down blood clot, was incised and drained. Healing took place rather promptly and the patient soon made an un-

eventful recovery without having any sign of deformity present. The scar at the present time is hardly palpable and a vacuum cup applied over the penis showed that erection was entirely normal, there being no lateral deformity.

The penis is subject to contusions, rupture, lacerations, incised and punctured wounds, luxation and strangulation. Traumatic rupture of the corpora cavernosa is looked upon by many members of the medical profession in a more or less humorous way, but although it is rare, it is a condition that may sometimes occur and may be followed by serious complications. The seriousness depends upon whether the urethra is injured or the erectile bodies ruptured. If the rupture is severe, scar formation and tendency to lateral deformity of the penis may result, which will interfere with coitus.

It is my opinion that the patient was rather fortunate, in view of the fact that the corpus sustained a slight rupture and left a small scar which evidently is slowly becoming absorbed. However, the prognosis should always be guarded. When an injury of this character occurs, one must make sure that the urethra is intact. If rupture of the urethra occurs, appropriate treatment should be carried out. The effusion of blood which always occurs in rupture of the corpora, provided that the rupture is not severe, as a rule will subside if the patient is at rest in bed, with the penis elevated and cold compresses applied. If the effusion continues, incision, ligation of the vessels, and suturing of the sheath should be resorted to.

C. Otis Rich<sup>3</sup> reports a case where a revolver bullet became imbedded in the shaft of the penis in a white male, age twenty-six. After removal of the bullet there was left a lateral deformity and erection was painful. Cases of penile injury have been reported by William S. Ehrich and others.

In conclusion I would like to emphasize the fact that conservatism rather than radical procedures should be employed.

[For References see p. 457.]

# TUNNELING METHOD OF SPINAL FIXATION\*

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AS our concept of the requirements in spinal fixation progresses, our methods should progress *pari passu*

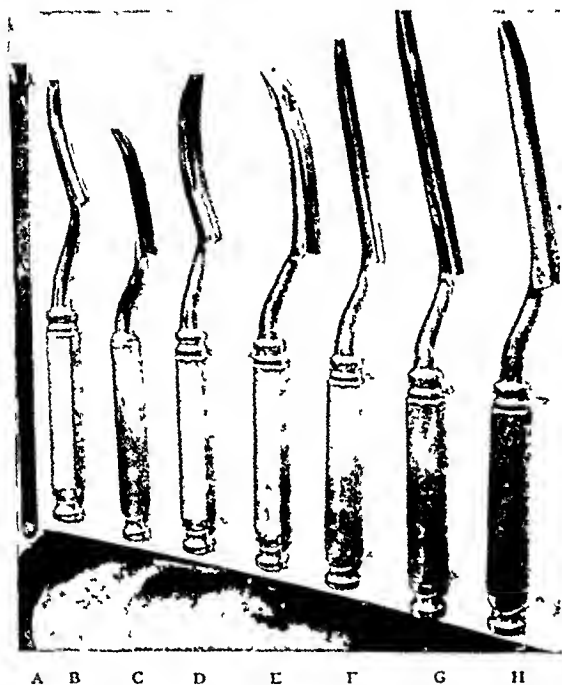


FIG. 1. Tunneling osteotome.

in simplicity and efficiency. By simplifying the procedure we extend its horizon.

The tips of the spinous processes, in the cervical region, are bound longitudinally by the ligamentum nuchae. This structure continues over the spinous processes of the thoracic and lumbar regions, as the supraspinous ligament. The broad, flat muscles of the back nearly all have their origin in this structure. In the cervical and upper thoracic regions the serrati superiores, the rhomboidei, and the trapezius arise from a more or less fused aponeurotic sheet, the nuchal fascia. The internal oblique and transversalis muscles of the abdomen, the serrati inferiores and the latissimi dorsi, cover the lower thoracic and lumbar regions with a broad, fibrous expansion, the *lumbodorsal fascia*.

It is to be noted that the fibers of these aponeurotic sheets are arranged *horizontally*, and that the muscle pull, throughout the spine is *away from the median line*, producing a physiological tension of the nuchal and lumbodorsal fascia. Here it would seem the idea of McBurney of splitting the fascial structures in the direction of their fibers, rather than cross-sectioning them, the "gridiron" method, would appear useful. William J. Mayo found the same idea useful, in his operation for umbilical hernia, and took a long step forward.

The adequacy of a graft, placed longitudinally in the spinous processes, has been shown. It appears that the graft should be so placed without dividing the fascia across its fibers. By preserving the fascia intact, a positive support would be secured, and *the back rendered immediately rigid by the action of the graft as a splint*.

In order thus to implant the graft, and secure bony contact, it becomes obvious that one must have access to the subfascial bony processes longitudinally. To secure this a special tool became necessary. The tunneling osteotome (Fig. 1) was devised, with a sharp chisel edge, a blade of adequate length and breadth, channeled on its ventral surface, presenting an inclined plane on its dorsal surface, with lateral walls of adequate height. It is bent like a trowel to admit of the blade's being brought parallel with the spinal cord. The reverse curve in the handle gives positive control and freedom from skin contact with the hand. The blade has been bent anteriorly and posteriorly to meet the varying requirements of kyphosis and lordosis.

The patient is placed prone upon the supporting apparatus (Fig. 2A) consisting

\* Submitted for publication January 19, 1931.

of head and shoulder rests and pelvic support, so constructed that it can be adjusted to any patient and secure support

is selected. A sharp tap of the hammer sections this process. This procedure is continued until five or more processes

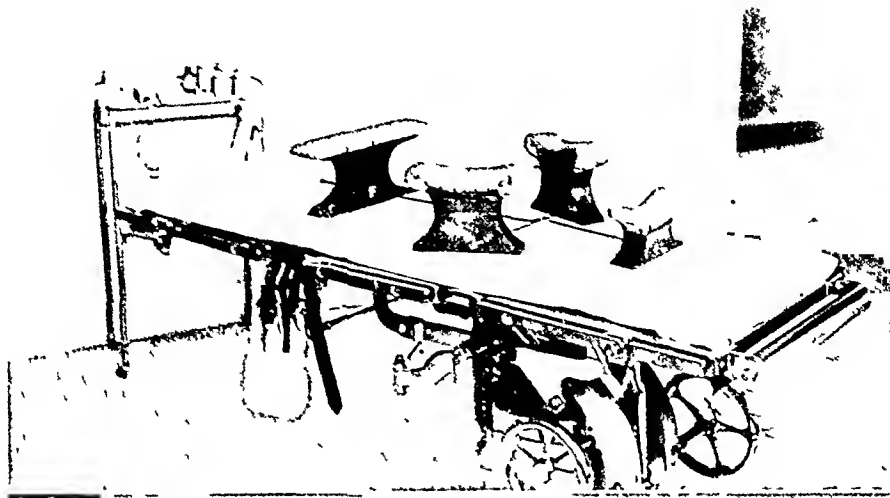


FIG. 2A.

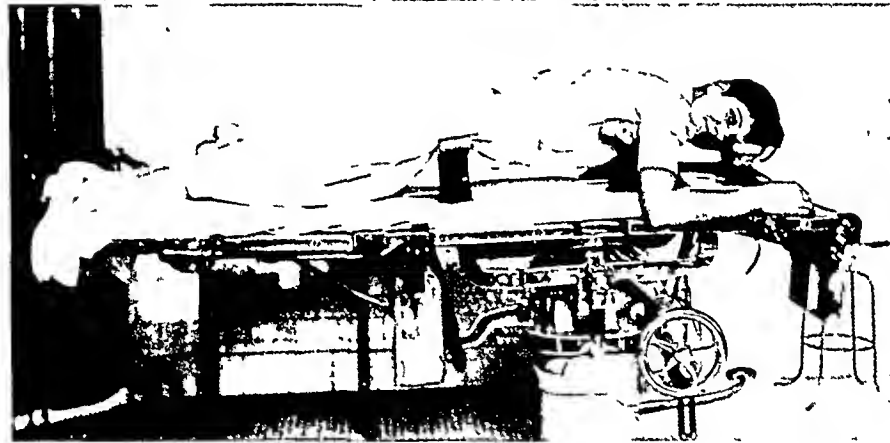


FIG. 2B.

FIG. 2A. Supporting apparatus.

FIG. 2B. Manner of use; note free chest and abdomen, securing full thoracic and abdominal breathing.

at any point desirable. Here he rests comfortably with free thoracic and abdominal breathing (Fig. 2B).

A transverse incision,  $1\frac{1}{2}$  to 2 in. in length, caudad to the second spinous process below the affected vertebra, through skin, subcutaneous tissue, fascia (in the direction of its fibers), and supraspinous ligament, gives ready access. The tunneling osteotome is introduced, through this incision, to the selected point on the caudad aspect of the spinous process. The process is nicked; the instrument brought parallel with the cord. A sharp tap of the hammer sections the process at this level. Advancing by the sense of touch, the correct level in the next process

are thus prepared. The blade of the chisel is now buried in its full length, *subfascially*.

The lateral walls of the osteotome have acted to elevate the tips of the sectioned processes on the dorsal surface of the instrument. A tunnel has been produced, into which a graft, full width of the groove in the osteotome, may be inserted without difficulty. For the purpose of simplifying this introduction, a flanged retractor (Fig. 1A and B) has been devised, with adequate hooks on the ventral surface, so placed as to retract the margin of the skin wound well away from the entrance to the tunnel, with sidewalls of sufficient height to form an adequate channel into which the graft may be dropped. The metal channel so

constructed engages the heel of the osteotome (Fig. 3), protects the graft from skin contact, and gives direction to the graft placed upon the stumps of the sectioned processes. The *fascial retraction* forces the distal fragments of the sectioned processes

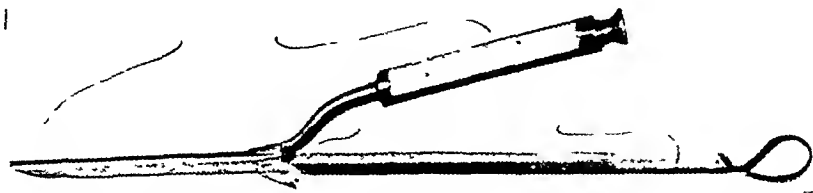


FIG. 3. Channel retractor, engaging heel of osteotome.

in its advancement. When properly engaged with the heel of the osteotome, it permits of the graft's being advanced into the tunnel without obstruction.

down upon the dorsal aspect of the graft, and the graft upon the stumps of the sectioned processes. Thus are produced two points of bony contact: the stump,



FIG. 4. Extreme kyphosis requiring a rib. (In this case posterior parts of two vertebrae, including pedicle, with articular and lateral processes, laminae and spinous processes, were completely removed. This permitted a fair degree of straightening. A cast was used. Three months after operation patient started to go to school and continued well, walking over 1 1/4 miles in all weather. She is still well and strong.)

The retractor is removed, the osteotome withdrawn, leaving the graft securely



FIG. 5 A.

FIG. 5 B.

FIG. 5 A. Type of case in which a rib would better meet the requirements. A straight graft was used, but a rib would be better.

FIG. 5 B. Same case after operation.

ventrally, and the distal fragment, dorsally, at each vertebra throughout the length of the implanted graft. No limiting membrane is permitted to intervene at our points of contact.

The slit in the fascia and the supraspinous ligament are whipped together by a running suture of 000 catgut, and the



FIG. 6 A.

FIG. 6 B.

FIG. 6A. G. I. M. Typical tuberculous spondylitis, bodies of two vertebrae gone, patient helpless. Straight tibial graft,  $5\frac{1}{2}$  in. long,  $1\frac{1}{2}$  in. wide, full thickness of cortex used. Patient up and about without brace or cast in six weeks.

FIG. 6B. G. I. M., after operation. Patient has remained comfortable as far as back is concerned, he is now giving evidence of a tuberculous psoas abscess, pointing on inner aspect of upper thigh, which is giving some trouble. He has been active and strong and gained 40 lb. in weight.



FIG. 6C. G. I. M., after operation; note high point.



FIG. 6D. G. I. M., lateral skiagraph before operation.



FIG. 6E. G. I. M., skiagraph after operation, illustrating presence of graft.



suture is returned, subcutaneously, for the approximation of the skin. This completes the operation. The time necessary

of bone. From this point two processes are sectioned with the osteotome, above the affected vertebra. Our instrument is re-

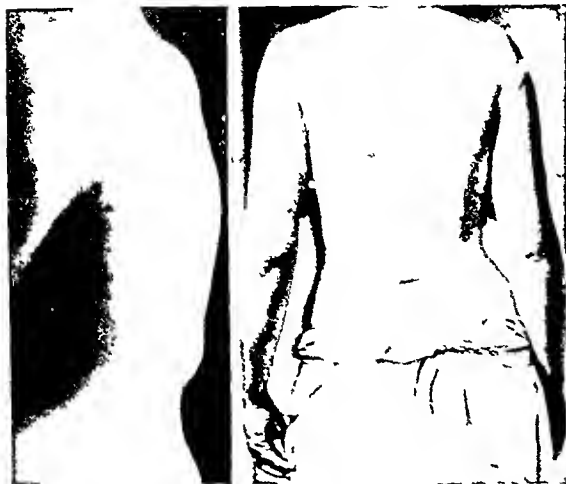


FIG. 7 A.

FIG. 7 B.

FIG. 7A. D. M. Kummell's fracture. This case was reported in *Bone & Joint Surg.*, Oct., 1927. It is included in this report because of its uniqueness in disregard of all orders, and warnings. It has served to give confidence in the security of the method. It proved that what has been regarded as a major procedure is really a simple minor affair. See Case 1. FIG. 7B. D. M. After operation.

for its performance has been from seven to ten minutes.

The operation as described applies only to those cases in which a straight graft can be used. It has been found that in cases of extreme kyphosis, as illustrated in Figures 4, 5A and 5B, that a curved bone is needed. Here a rib, full width and thickness, of adequate length, being flexible, adjusts itself admirably to the requirements.

For the introduction of the curved rib, the tunnel cannot be made easily and safely from the second vertebra below, to the second vertebra above the affected vertebra; so it becomes necessary to find a different method of approach for these cases. An instrument with the proper curve is selected. The incision is made, as before, in the direction of the fibers of the lumbodorsal fascia, and of the same dimensions, caudad to the spinous process of the affected vertebra. This spinous process is removed with a rongeur from lamina to tip, leaving a very small distal segment



FIG. 7C. D. M. On the seventeenth day following operation.

versed and the skin is retracted as before. The processes of two vertebrae are sectioned below the affected vertebra. The end of the rib is introduced into the tunnel created by the osteotome. It is twisted slightly to one side, and pushed downward between the fascia and lumbar or dorsal muscles, as the case may be, until the entire graft is buried. The proximal extremity is now introduced into the osteotome, which has been reinserted into the upper tunnel (as a grooved director, ventral surface down), for the accurate emplacement of the upper end of the graft. This takes no time and is easy of accomplishment. The graft is adjusted to its proper position in the act of inserting the upper portion in line, upon the stumps of the sectioned processes. The wound is closed as before.

The spinous process of the affected vertebra, if left full length, would still



present a high point, posteriorly to our graft (Fig. 6c). When the high point is objectionable it may be resected, leaving a

treated, are not aware that their backs have been invaded. They know about their shins. They can see the dressings. Even these



FIG. 7D. D. M. Playing with her two-year old child, six weeks after operation. She has never worn a brace or cast, and has remained strong and well to date.

small tip of the distal fragment to be pulled into contact, and no sharp elevation remains.

You will observe that, whether straight or curved, the graft is applied with a broad, flat surface to the stumps of the sectioned processes. There has been no desire to introduce a graft of these dimensions on edge; in fact it would be undesirable.

That good bony contact is secured is proved by the fact that these grafts remain visible in the x-ray from eight to ten years following operation (Fig. 8). They are not absorbed.

The immediate comfort of the patient, following operation, is surprising, and has been attested to by many patients (Figs. 7A-F). Many of the children so



FIG. 7L. D. M. A-P skiagraph four years after operation showing graft.

wounds cause no pain, when the dressings are applied in such a manner, with longitudinal strips of adhesive, to the anterior surface of the leg, as not to permit a drag on the dressings in bed.

The postoperative care is most simple. No retentive dressing is applied, no cast, no brace. The patient is permitted to lie on his back on a flat bed. Movements in bed, in the horizontal position, are permitted *as early and as freely, as the patient desires*. The reason for this is that a long graft, planted longitudinally, *under the uncut fascia*, is held rigidly in place by this structure, and is, thus, itself the supporting agent upon which we depend. The fixation of the spine by a support so inserted is immediate and complete. The position of the graft is secure, as is shown by a number of cases in which early movements of the most extreme type failed to dislodge the graft and caused no trouble whatever. A wooden peg, so placed, would give the same relief from pain, but the autogenous

graft of living bone will, in time, fuse with the fragments of the sectioned spinous processes in such a way as to give a

procedures are: its simplicity, facility of performance, freedom from unsightly scars, small amount of exposure incident to the



FIG. 7F. D. M. Lateral skiagraph four years after operation showing graft.



FIG. 8. G. K., aged twenty-four. Sacralization fifth lumbar vertebra. "Batwing" right lateral process, fused with sacrum and ilium; fracture of right lateral process. See Case 11.

permanent, rigid support where most needed.

Osteogenesis is known to be slower in the region of the spinous processes than in the long bones. The implantation of a long-bone graft into the field stimulates bone growth.

The reparative process by which a tuberculous spine is cured is necessarily slow, and it may be true that the complete cure of the condition requires long lapses of time. But the relief from pain, and the freeing of the patients from long periods of invalidism render it possible for them to get out and play in the sun, the best cure. I have endeavored to keep my patients from sitting or standing until the graft should be fixed by the formation of a good, strong callus; that is, from four to six weeks, but I have failed to secure such conduct in a few cases, with such results as to give me more and more confidence in the safety of a wider range of freedom.

The advantages of this method of implantation, as compared with recognized

small incision, lessening trauma to the essential structures, freedom from introduction of sutures or ligatures for the retention of the graft *in situ*, freedom from surgical shock, immediate fixation of the painfully mobile spine, freedom from the necessity of postoperative braces or casts, and early return to normal activity.

The development of this method in the course of a fairly busy surgical practice in the country, might be of interest.

In attempting to do an Albee operation on a boy with a decided kyphosis (Fig. 10 A-C) I was embarrassed, on exposure of the field, by the length of the graft required, and by the fact that I could not succeed in fastening the ends of my graft down to the bone where I felt it necessary to secure bony contact in the entirety of my graft. Lacing it down with kangaroo tendon did not seem quite adequate. It dawned on me that if I could hang the ends under the uncut fascia at the upper and lower extremities of my long back

incision, I would get better approximation of the graft to my split spinous processes.

I secured a graft from the tibia a bit longer than was required to reach the affected vertebrae which I desired to include in the fusion, and in order to get a full effect of the straightening of the back I inserted the lower end under the uncut fascia, pushing it down until the upper end could be similarly engaged under the uncut fascia at the upper extremity of the incision. When I succeeded in getting the ends tied down under the uncut fascia, I had produced a gentle curve in the graft, and the graft itself acted as a long spring for the correction in a very pronounced manner of the kyphosis.

I was surprised at the intimate application thus secured of the graft to the mutilated spinous processes without a suture. The sutures were introduced however, giving added security to the emplacement of the graft, and the wound closed.

The boy made an uneventful recovery. The graft stayed put. I had succeeded in getting enough straightening of his back to add  $2\frac{1}{2}$  in. to his height, and had put the abdominal muscles, which were greatly shortened in the position of gibbus, upon the stretch until he roared with pain at the tension. This was the only pain he had and was gradually relieved as the abdominal structures and the overhanging thorax adjusted themselves to the upright posture. The photographs (Figs. 10, A-C) illustrate this case. The lateral skiagraph is not available. The young man is a telegrapher and is today, after fifteen years, sound and well.

The operation has been performed in approximately 100 cases, indiscriminately, without attempting to make a record for the procedure.

The only fatalities which might be traceable to the procedure, have been 3 cases which never should have been included in the series. One was a child of two years of age, so anemic that it died under the anesthetic before an incision was made. My experience prompted me to attempt to alleviate this child's pain.

The second was an old man who died shortly after the operation from nephritis.

The third was a child who died shortly



FIG. 9. A. L. D., aged twenty-five, showing the use of a rib in the lumbar region.

after the operation from miliary tuberculosis. If I had been attempting to protect the procedure from adverse criticism these cases would not have been touched.

The remainder of the series have, without exception, presented a successful issue. Uniformly pain has been relieved, fixation been secure, and so far as a mechanical fixation can be successful have resulted in cures.

#### CASE REPORTS

CASE 1 (Fig. 7).<sup>1</sup> Patient aged 20, seen on April 2, 1927. Inspection showed kyphosis in the lumbar region. She was run over by an automobile one year before and "jack-knifed" to such an extent that both hips were dislocated, and her back broken at the third lumbar vertebra. She was carried home, the dislocated hips reduced, but the back was overlooked. She was kept in bed for four weeks. Immediately upon assuming the upright posture, the kyphosis became manifest. It had become more pronounced, giving her daily pain to such an extent as to incapacitate her. Skiagraphs one

<sup>1</sup> *Bone & Joint Surg.*, Oct., 1927.

year after the injury, showed typical Kümmell's fracture of the third lumbar vertebra, fracture of left lateral process of third lumbar vertebra.

the ward where she was to be placed, she climbed out of the wheelchair unaided, walked over to the bed and retired.



FIG. 10 A.



FIG. 10 B.



FIG. 10 C.

FIG. 10A. E. M. Pronounced kyphosis, Kümmell's disease.  
FIG. 10B. E. M. After operation.  
FIG. 10C. E. M. After operation.

Fixation was advised and operation performed April 8, 1927. A straight tunnel was driven from the fifth to the first lumbar vertebra, sectioning the posterior processes subfascially at a safe level from the spinal cord. A 1 in. incision was used for entering the osteotome. A  $5\frac{1}{2}$  in. graft,  $\frac{3}{8}$  in. wide, full thickness of the cortex of the tibia, bare of periosteum, was secured and inserted into the tunnel. The tunneling osteotome was withdrawn; wounds were closed with 000 catgut, simple dressings were applied and patient was put to bed on a flat mattress, on her back. Operation required thirteen minutes.

The postoperative treatment of this case and the patient's rapid recovery read like a combination of Baron Munchausen and the Arabian Nights.

On the third day following the operation, feeling so inclined, the patient arose and used a vessel at the side of the bed, sitting in the upright posture. She has never used a bedpan. At the end of a week she got up and walked, climbing into a wheelchair unaided, to be transferred to another floor. On arrival at

Two weeks following the operation she walked out of the hospital and rode home in a Ford. On the sixteenth postoperative day she took a joy-ride to a neighboring town in a Ford, *driving the car herself*.

On the seventeenth day she came to the writer's office, spent the afternoon pleasantly conversing and walking about the place; took supper with him and went with him to the meeting of the Jasper County Medical Society, where her case was presented at the clinic. In order to get to the room in which the society met, she walked up the flights of steps at the approach of the building, and up a long flight of stairs to the second floor, unaided.

The only discomfort she felt was a slight stiffness of the scar on the shin from which the bone had been removed. Her back was free from pain; she looked and acted as though she had nothing the matter with her back; she stooped and picked up a knife from the floor as easily and comfortably as if she had never sustained an injury. In the fourth week following her operation the patient attended a carnival being held in town. Upon entering a dark room

and sitting down on a bench, the bench was suddenly jerked out from under her and she was precipitated unexpectedly down a long incline, arriving at the bottom with a bump. She rode the merry-go-round, indulged in all the trick performances, and as a climax to her effort, apparently determined to break her back, rode what she called the "Whip" five times in succession. After these strenuous trials she is convinced that her back is strong.

CASE II (Fig. 8). Low back injury caused by horse falling on patient while in service during the war. Patient came to my office walking with great difficulty, dragging one leg with a painful sciatica. A brace which had been applied two years previously had benefited him, but had not cured him. The skiagraph showed a "batwing" right lateral process of the fifth lumbar vertebra which had been fused with the sacrum and ilium, but which in his accident had been torn loose from its moorings to the ilium, producing a painful situation. Fusion was recommended, and accepted in the hope of relief. Operation, June 1920: with a straight  $\frac{1}{2}$  in. carpenter's chisel, tunneling from well down on the sacrum under the fascia, lifting bone with the fascia, upward through the spinous processes of the fourth and fifth lumbar vertebrae; a graft  $\frac{1}{2}$  in. wide, 4 in. long, full thickness of the cortex, was secured

from the tibia, and inserted in the tunnel. The patient was put to bed on a flat mattress without supporting apparatus. He sat up on the side of the bed in fourteen days, his pain decidedly relieved; was up and about in four weeks, and left the hospital in six weeks. The irritation of the sciatic nerve continued slightly to embarrass him for several weeks, but gradually disappeared entirely. The skiagraph (Fig. 8) illustrates the presence of the graft eight and one-half years after operation. The year following the operation the young man took a course in geology at the Missouri School of Mines. During the course he went on field trips with the other students, and has continued active in geology. This case illustrates the use of the straight graft in the lumbar region. Complete cure.

CASE III (Fig. 9). Osteoarthritis of the second and third lumbar vertebrae; painful back rendering patient helpless. Operation, Feb. 1925: A section of the right tenth rib,  $4\frac{1}{2}$  in. long, entire rib, inserted in the tunnel extending from the third to the fifth lumbar vertebra, fixing the affected joint. A curved osteotome (Fig. 1, E) was used to drive the tunnel. The patient was up and about in four weeks, and left the hospital in six weeks; has been earning a living at hard labor to date. Complete recovery.



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\* Continued from p. 447.

## OBSERVATIONS ON INGUINAL HERNIA\*

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EVER since the establishment of the Workmen's Compensation Laws the question of whether or not a hernia is the result of a specific injury has been the subject of a great deal of discussion both by the legal and the medical professions. One of the commonest questions that we are asked to decide is whether a hernia is spontaneous or due to trauma, and whether it is recent or old. After some experience with this type of abnormality we have arrived at certain conclusions which in our opinion is very definite.

As we know, inguinal herniae are divided into the direct and indirect types. The direct, in which the protrusion presents at the triangle of Hesselbach, mesial to the deep epigastric artery, is a very rare type, difficult to repair, and we have never seen a case of this form in which there was a claim of a traumatic etiology.

The indirect inguinal herniae protrude through the internal inguinal ring, external to the deep epigastric artery and are of two types, the incomplete and complete. The incomplete type is often erroneously called direct because the protrusion is directly forward instead of extending down the inguinal canal. In some cases the incomplete type is an early stage of the complete inguinal hernia, but most often the incomplete type remains such without extending into the canal or scrotum.

In the complete type of indirect inguinal hernia the sac presents at the external inguinal ring and progresses downward into the scrotum. This type is by far the most common form of hernia and is most frequently the subject of legal controversy.

About ten years ago we conceived the idea that the term "rupture" was a misnomer, and that an indirect inguinal hernia extending down the canal was due

entirely to the dilatation of a preexisting patent funicular process. Since then, to the present we have never seen a case of recent hernia that showed features to disprove that idea. In normal males, about the time of birth, the funicular process becomes obliterated. In a few cases this process remains entirely open forming a communication between the peritoneal cavity and the space of the tunica vaginalis, and leads to the formation of the type of so-called congenital hernia. This generally manifests itself during infancy. A more common occurrence is the closure of the testicular end of the process with the peritoneal end remaining open. In such a case this patent funicular process forms a narrow peritoneal sac communicating with the peritoneal cavity. In some cases this process is obliterated in its lower portion, but in most instances it exists as far as the upper pole of the testicle. Given such a condition it is easy to see how repeated or constant strains that increase intra-abdominal pressure would gradually stretch the peritoneal opening of the funicular process. The pressure of the gut, or more commonly the omentum, after dilating the upper opening, can easily distend the remaining portion of the process as its walls become thinner as they extend downward.

It is our belief that all cases of complete indirect inguinal hernia are formed in this manner. In a few cases we believe that we have observed the funicular process return to its prehernial size. This has been seen in patients on whom we have demonstrated a definite sac, but on account of some temporary contraindication to operation we have put them to rest for one to two weeks. At the end of this time no sac could be demonstrated, but the patient

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was operated on and in each one a narrow patent funicular process was found showing that the dilatation had not become permanent and with the removal of increased intra-abdominal pressure the sac had returned to its former diameter. In quite a few cases the funicular process had not become entirely dilated at the time of operation and it could be demonstrated as a fine tube continuous with the lower portion of the sac.

In several instances, a patient with a complete inguinal hernia on one side only, has given the history that at times a swelling has appeared on the opposite side for a short time and then disappeared. Examination of this side revealed no palpable sac. At the time of operation of the apparent hernia, the opposite side was explored, and in each instance an open funicular process was found.

In almost every case of recent hernia, in which the sac has not had time to become thickened by irritation, on opening the sac, one finds at the upper part of the neck a ring or band of subperitoneal connective tissue. In some cases this thickening is barely perceptible, in others it is present as a definite band, and rarely as a partial but definite diaphragm. This thickening represents the level at which nature should have obliterated the upper end of the funicular process. To find this band or zone of thickened tissue in the neck of the sac is most important in the cure of the hernia. We believe that every case of recurrence that we have had has been due to the ligation of the neck of the sac below this line, in which case we left a portion of the upper funicular process to serve as funnel for the starting point of a new sac.

Moreover, we also believe that if the neck of the sac is ligated at this thickened portion, where nature should have closed it, that the hernia will be cured, and that the transplantation of the cord and other elaborate methods of closure are entirely superfluous. After removing the sac, we simply bring the edge of the internal oblique muscle to Poupart's ligament with

three or four sutures, and then close the defect of the aponeurosis of the external oblique muscle and skin.

As mentioned before, the formation of spontaneous scrotal hernia is due to constant or repeated strains gradually distending the patent funicular process. In traumatic scrotal or complete indirect inguinal hernia the distension is caused by a single strain. The condition is one of aggravation of a preexisting congenital abnormality. The only difference between the spontaneous and the traumatic type is that the former is gradual, the latter sudden. From a clinical standpoint there is one marked difference between the two types. In the spontaneous type the stretching of the funicular process is slow and gradual and the patient suffers little if any pain or discomfort. He often does not know that he has a hernia until he accidentally discovers the swelling. In the traumatic type, on the other hand, the sudden stretching of the upper opening of the funicular process always causes sudden and disabling pain. In most cases this is accompanied by nausea and vomiting. It is the general experience that in operating under local anesthesia, pulling or stretching of the parietal peritoneum causes patients to complain of pain, and they are also frequently nauseated. It is inconceivable that the sudden stretching of the peritoneum at the neck of the sac, in a person without a local anesthetic, would not cause him to suffer the same symptoms. In fact, in every case of traumatic hernia of this type the patient gives a definite history of immediate disabling pain, frequently accompanied by nausea and more or less shock. The protrusion of the sac through the external ring may not appear before twelve to twenty-four hours. Tenderness about the inguinal region is immediate and may last for several days. We have never seen extravasation of blood or ecchymoses unless the injury was in the form of a direct blow over the inguinal region.

Occasionally the patient gives the history

that after the initial pain he sits or lies down for an hour or two, after which he feels better and resumes his work. This is not incompatible with a traumatic hernia. But when a patient claims that his hernia is due to a specific trauma and does not give the history of an immediate disabling pain, he is either grossly mistaken or is not telling the truth.

We are often asked to try to determine the duration of a hernia by the size of the sac. In a patient with a thick scrotal sac the size of an orange who claims that it is due to an injury of a few days before, we know that there is a mistake somewhere, but in the majority of thin-walled sacs it is impossible to arrive at any conclusion as to their duration. The reason is that the size of a recent hernia depends largely upon the length of the open funicular process. A spontaneous hernia of a year's duration may extend only  $\frac{1}{2}$  in. beyond the external ring because the funicular process was only open a short distance. Again, a traumatic hernia may fill a sac extending to the upper pole of the testicle within twenty-four hours after the injury. So we feel that in a thin-walled sac it is impossible to determine the duration of the hernia by its size.

Many consider the size of the external inguinal ring as an important factor in the causation of indirect inguinal hernia. It is true that in very large or old herniae the ring becomes enlarged, but in the smaller or recent cases our experience shows that there are no more cases with the large rings than with the small. Again we see men who do the heaviest form of manual work, who have very large rings with no signs of hernia.

An interesting observation was made on naval recruits during the late war. One of us examined and accepted several thousand men. A record was kept of the physical findings on each man which included the size of his external inguinal rings. It is an unpleasant custom in the Navy that when an enlisted man develops an abnormality a few months after his

enlistment, the examining surgeon is sent a very disagreeable letter asking why he accepted a man with such a defect. Quite a few such letters were sent back concerning men who had developed herniae and in searching for an alibi in the record of the size of their rings in a very few instances did the record show enlarged inguinal rings in those men who had developed herniae.

While it is very difficult or even impossible to determine the duration of a hernia with a thin-walled sac by physical examination, this point may be easy to determine at the time of operation. It is not known how long it takes for the formation of dense peritoneal adhesions, but it probably takes at least sixty days. If on opening the sac one finds its walls thickened, if there are bands of connective tissue in the walls of the sac, or if there are firm adhesions between portions of intestine or omentum to the wall of the sac, we can safely conclude that the hernia is at least two months old and probably older. Diverticula of the sac or a sac with multiple compartments are an indication that the hernia is many months old.

The presence of an elongated lipoma in the inguinal canal in a patient with hernia has been interpreted in various ways. Some hold that the presence of lipoma predisposes to hernia. Others believe that the presence of the lipoma is an indication that the hernia is of long standing. We do not hold to either of these views, but believe that this elongated mass of fat is an attempt on the part of Nature to support the open funicular process, an attempt at repair of Nature's failure to complete a developmental process. We consider it a process similar to the so-called lipoma or fat pad found in patients with spina bifida occulta.

In the case of incomplete indirect inguinal hernia, that type in which the sac does not present at the external ring, we have two forms. The first is identical with the complete form except that the open funicular process is very short, or



that the process is very narrow and enough time has not elapsed to fully dilate the process. In this type of case the swelling is just above the external ring and if due to an open funicular process will gradually progress downward.

The second type of the incomplete indirect inguinal hernia (often erroneously called direct) has no open funicular process. The sac is simply a bulging of the peritoneum through the internal ring. Before this bulging can take place there must be a separation or splitting of the fibers of the external oblique aponeurosis. This may occur as a spontaneous process in thin and poorly developed individuals, but these patients rarely complain of pain or discomfort. When this same type occurs as the result of a sudden strain there is the sudden disabling pain, nausea and local tenderness. As a rule these symptoms are more marked than in the case of stretching the mouth of the funicular process. Operation is seldom indicated as in our experience the patient recovers completely within one to three weeks of complete rest, during which time the tear in the aponeurosis heals and the bulging

peritoneum shrinks back to normal. Occasionally, spontaneous healing fails to take place and an operative repair must be done. No sac is found, but the bulging peritoneum should be opened, overlapped and sutured.

#### CONCLUSIONS

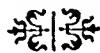
Traumatic inguinal herniae occur as complete and incomplete indirect herniae.

Complete indirect inguinal hernia whether spontaneous or traumatic, is in our opinion the result of the dilatation of a preexisting funicular process.

Incomplete indirect inguinal hernia is either the early stage of the complete type or it is the bulging of the normal peritoneum following a giving away of the fibers of the aponeurosis of the external oblique.

In all types of traumatic herniae the sudden stretching of the peritoneum causes immediate disabling pain often accompanied by nausea. If these symptoms are lacking, the hernia is not the result of a single strain.

In herniae with thin-walled sacs it is impossible to determine the age of the hernia by the size of the sac.



# ABNORMALITIES IN THE SHAPE AND POSITION OF THE DUODENUM\*

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## CASE REPORT

**CASE I**, C. G. male, aged thirty-six.  
Past History. In 1922, operation for perforated duodenal ulcer: suture and drainage: uneventful recovery.

Present Illness. For six weeks has complained of cramp-like pains in the epigastrium, followed by vomiting of food after every meal; on one occasion the vomitus was coffee-ground in character. Has lost weight and is constipated.

*Physical Examination:* A slender, nervous individual. There was slight rigidity of the upper right rectus muscle, stomach extended from fifth rib to navel.

*Test Meal:* Free hydrochloric acid in excess.

*Braid Test:* Slight blood stain obtained from the duodenal area just beyond the pylorus.

*X-ray Examination:* A niche in the pyloric region: moderate six-hour gastric delay.

*Diagnosis:* Duodenal ulcer with partial pyloric obstruction.

*Operation*, Nov. 28, 1928.

*Pathology:* Indurated pylorus did not admit the tip of finger. Ulcer upon anterior surface of duodenum close to the pylorus. The first portion of the duodenum was adherent to the liver: the first and second portions were dilated. The inferior duodenal angle bulged prominently through the posterior peritoneum, close to the hepatic flexure of the colon and the third portion extended to the left towards the mesenteric root.

The jejunum did not present in the usual position at the left of the spine, but entered the peritoneal cavity through a firm arched opening in the mesentery of the ileum close to the ileocecal region.

It did not ascend to the under surface of the transverse mesocolon but passed to the left in the lower abdomen.

The duodenum was constricted at the point where it passed through the mesentery and dilated above.

Traced backwards, it extended obliquely upward below the mesenteric root and turned to the right to form the inferior duodenal angle.

*Procedure:* Pylorotomy: end-to-end anastomosis (Billroth 1): opening in the mesentery enlarged.

*Result:* Satisfactory convalescence, remains free from symptoms.

**CASE II**, male, aged eighteen.

Past History does not apply.

Present Illness: one day before admission to Gouverneur Hospital, vomited and complained of pain in the lower left quadrant. Upon his admission, there was rigidity of lower left rectus muscle, leucocytosis and slight temperature.

*Diagnosis* made of acute diverticulitis.

At operation the cecum and appendix presented in the left iliac fossa.

The acutely inflamed appendix was removed and convalescence was uneventful.

It was recognized that this was probably a case of non-rotation of the colon and before leaving the hospital a barium enema was given the patient which confirmed this opinion. It was further suggested that the duodenum had also failed to rotate as is usually the case with non-rotation of the colon. To determine this, a duodenal tube was introduced, its position in the duodenum confirmed by x-ray, and a barium emulsion was injected through the tube. The picture showed the barium extending downward to the right and not crossing the spine. It was therefore concluded that the duodenum had not undergone rotation.

## COMMENTS

The first case is of surgical interest because it was intended to do a gastroenterostomy. When the duodenojejunal angle was looked for in its usual location, it could not be found. It was then sought for at the right of the spine but as it did not present at this point, a systematic search was made, commencing at the ileocecal junction and inspecting all the loops of the

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small intestines until the opening in the mesentery was reached close to the starting point.

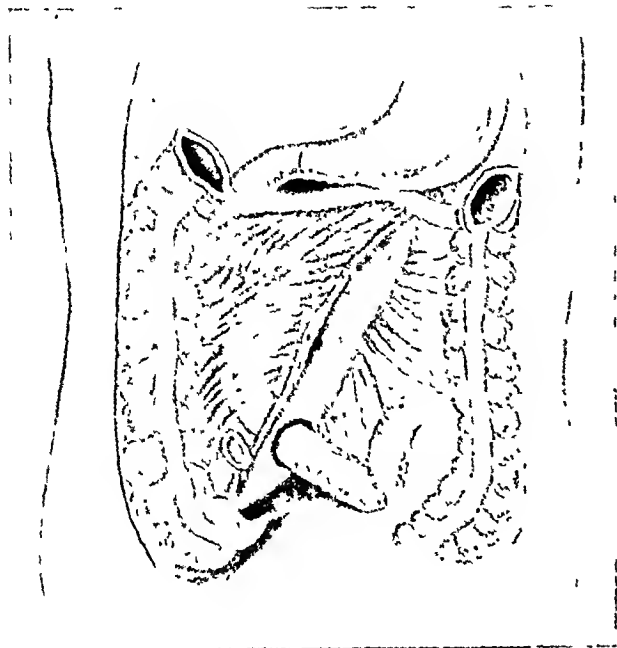


FIG. 1. Abnormal position of duodenum. Transverse colon, jejunum and ileum removed. Third portion of duodenum passes to left to vicinity of mesenteric root and then turns downward, entering abdomen through a constricted ring in mesentery close to ileocecal junction. Duodenum is dilated immediately above this point. Personal observation.

The dilatation of the duodenum above the mesenteric opening caused some doubt as to the adequacy of the Billroth I operation, but it seemed the only method available and the plastic operation upon the mesenteric opening has apparently allowed satisfactory duodenal drainage.

This particular anomaly does not appear to have been previously described but has probably been recognized, as one writer refers to a duodenum entering the abdomen to the left of the cecum.

The case of non-rotation of the duodenum accompanying non-rotation of the colon, was in this instance of anatomical interest only, but that it may complicate surgical procedures, is shown by a case, described by Mumford, in which the duodenojejunal junction was at the right of the vertebral column. A short loop posterior gastroenterostomy, for pyloric obstruction, terminated fatally, and au-

topsy showed that, as the stomach contracted, it had torn loose from the anastomosis resulting in peritonitis.



FIG. 2. Non-rotation of colon. Left-sided appendicitis after operation. Personal observation.

#### GENERAL CONSIDERATION

Study of the literature reveals a number of anomalies in the shape and position of the duodenum. Some of them are congenital and others are dependent upon variations in the length and fixation of the duodenum, and the shape of the abdomen, or are secondary to changes in the stomach, gall bladder, pancreas, liver, colon and right kidney.

Among the more frequent variations are the following:

*Non-rotation:* Non-rotation of the duodenum regularly accompanies non-rotation of the colon and may occur independently.

The duodenojejunal angle is then at the right of the vertebral column and the duodenum is not crossed by the mesenteric root.

In the simplest form, the third and fourth portions are lacking, the first and second portions curve convexly to the right and

angle is prolapsed. This is usually found in individuals with a contracted abdomen but is probably favored by abnormal

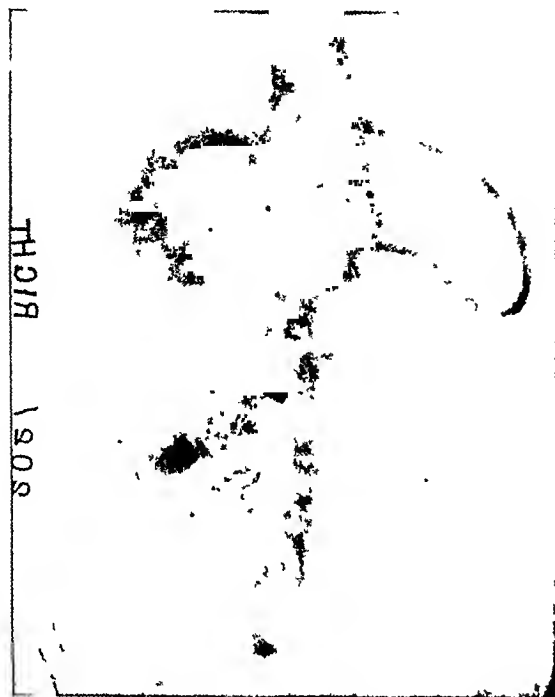


FIG. 3. Non-rotation of duodenum accompanying non-rotation of colon. Tube has been introduced into duodenum and barium injected through tube is distributed to right of vertebral column. It is the rule for the duodenum to enter abdomen without crossing the spine if colon has not rotated. Personal observation.

become intraperitoneal below the hepatic flexure of the colon.

**Duodenum Mobile:** In this condition the fetal mesentery persists so that the duodenum is mobile. It has been associated with non-rotation of the duodenum.

The condition was described by Roud in 1898 but the name was applied by Miyaki in 1916.

**Duodenal Ptosis (Chilaiditi, 1911):** The following forms have been described:

A. The first portion is elongated, the superior angle is fixed and is more acute than normal, so that motility is interfered with. It is usually secondary to gastropsis, which causes a constant drag upon the superior angle.

B. The first portion and the superior angle are normal but the second and third portions are elongated and the inferior



FIG. 4. The duodenojejunal angle appearing above lesser curvature of stomach, sometimes giving an x-ray picture suggestive of diverticulum or ulcer niche.

length of the duodenum, and ptosis of the right kidney and hepatic flexure of the colon.

C. The superior angle prolapses, the first portion is displaced in front of the second and third portions. This is favored by laxity of the hepatoduodenal ligament.

D. The entire duodenum prolapses as far as the mesenteric root or the duodenojejunal angle.

E. At rare times the duodenojejunal angle yields and total ptosis occurs.

This form is associated with marked mobility of the pancreas.

**Busi's Kink:** A kink in the second portion was described by Busi in 1912.

It is attributed to elongation and ptosis of the second portion with fixation at the ampulla of Vater due to traction by the unyielding hepatic and pancreatic ducts.

The chief interest lies in the roentgenographic interpretation.

**Expansion of the Duodenal Curve:** Pathologically this occurs with pancre-

atitis, cysts and lesions of the retroperitoneal lymph nodes.

It is not unusual however, to observe a wide curve in large individuals with a broad subcostal arch, in whom the duodenum is elongated without other pathology.

Its roentgenographic recognition may be of value in differentiating tumors in the region of the head of the pancreas from other upper abdominal lesions.

*Changes in Shape:* The duodenum may be triangular or describe a complete circle, the duodenojejunal angle being approximated to the pylorus.

An elongated segment may assume a serpentine or s shape, turned on its side and curving in front of the left kidney.

The third portion may ascend to the right of the second portion and cross to the left, (a) behind the second portion, the first portion or the pylorus, (b) in front of the second portion.

The third portion may ascend vertically to the left of the second portion but without crossing the vertebral column. In its course it may be retroperitoneal or intraperitoneal.

The duodenum may ascend to the normal position of the duodenojejunal angle and then turn to the right, crossing the abdomen to the right of the mesenteric root.

The duodenojejunal angle may ascend to a point above the lesser curvature of the stomach, giving the appearance roentgenographically of a diverticulum or an ulcer niche.

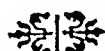
*Symptoms:* These anomalies may be of anatomical interest only, or may complicate roentgenographic diagnosis and surgical procedures, particularly gastroenterostomy.

They may moreover give rise to intermittent kinking with pain and obstructive symptoms varying with the relation of the interference to the ampulla of Vater.

*Treatment:* In many cases treatment is not indicated or relief may be obtained by postural treatment and supporting belts.

In some instances surgery is required.

Ptoxis of the first portion may be relieved by gastropexy or duodeno-duodenostomy. A mobile duodenum may be fixed by duodenopexy. A lesion beyond the inferior angle may be treated by duodenojejunostomy.



# A NEW TREATMENT OF PEPTIC ULCER

## A PRELIMINARY REPORT\*

GEORGE P. PITKIN, M.D., F.A.C.S.

HACKENSACK, N. J.

THE purpose of this communication is to make a preliminary report of our results in 127 cases of gastric and duodenal ulcer treated by a new method devised by the author.

The preparation used is a combination of foreign proteins derived from non-pathogenic schizomycetes, reinforced by lipoids and animal fats, with emetine.

We are forced to believe that a large percentage of peptic ulcers can be healed in from six to ten weeks by this agent given intravenously, that in a short time symptoms will disappear and the patient can go on a full unrestricted diet, even including alcoholic beverages with freedom from gastric distress.

We feel justified in our conclusions from the results obtained in a series of 310 cases, 127 treated by the author and the others by co-workers. The latter will report their findings, as soon as each individual series is sufficiently large to allow of definite conclusions.

The cases treated may be classified as follows:

Men 111

Women 16

Acute ulcers of less than six month's duration 9

Of more than six months 118

Gastric ulcers 6 (including 2 penetrating)

Duodenal ulcers 121 (including 2 penetrating)

Ruptured duodenal ulcers 5

Syphilitic ulcer 1 (duodenal)

Duodenal ulcer with chronic appendicitis 5

Duodenal ulcer with gastroptosis 3

Hematemesis 3 (gastric 1, duodenal 2)

Hematemesis after gastroenterostomy 1 (duodenal)

Hemorrhage from bowels 2 (duodenal)  
Cases previously treated by duodenal feeding 3

Pain persisting one or more years after the repair of a ruptured duodenal ulcer 3

Pain persisting after gastroenterostomy for ulcer 4

Appendectomies for relief of pain without results 5 (by other surgeons)

Cholecystectomies for pain without results 3 (by other surgeons)

Paraduodenal adhesions for relief of pain without results 1 (by other surgeon)

Results of intravenous medication:

Pain relieved after first injection 76

Pain relieved after second injection 16

Pain relieved after third or fourth injection 20

Pain relieved after five or more injections 6

Acute pain relieved, sensation of heaviness remaining 5

No relief 4

The gastric or duodenal ulcer sufferer is in an unenviable position. The members of the medical and surgical professions will agree that our present-day treatment is not satisfactory. Medicinal therapeutic measures combined with strict diet may and often do relieve pain, and while the stomach contents are alkaline or neutral the patient experiences little discomfort. There undoubtedly is a certain percentage of cures under this regime, the exact number being very difficult to estimate, but in the vast majority of cases, indiscretion in diet or moderate indulgence in alcoholic beverages will invariably bring about a return of symptoms. The patient

\* Submitted for publication March 16, 1931.

usually remains a slave to diet and drugs to enjoy even a fair degree of comfort and health.

Innumerable patients after trying out medical measures with no permanent relief turn to surgical intervention hoping for a cure. Should surgery be resorted to, what is to be done, and what are the results? The members of the surgical profession are far from unanimous in their opinions of the proper procedure to follow in order to cure this condition. One group advocates gastroenterostomy, another faction advises gastric resection. Others claim that the only proper procedure is excision of the ulcer. Such diversity of opinion among the very best surgeons is an admission that the surgical treatment of gastric ulcer is far from being satisfactory. If a gastroenterostomy is performed a convalescence of several months may be anticipated. Marginal ulcers may develop necessitating a second operation, or, as so often happens, the patient experiences no relief from his condition. Should resection be resorted to, either a subtotal gastrectomy or a groove resection, the patient may be relieved of pain but he has undergone a severe risk and at best can only hope for a fair measure of relief and may go through life with vague digestive disturbances of more or less severity. When the ulcer is accessible and can be excised the best results undoubtedly follow. But we must not blind ourselves to the surgical dangers. There is always the operative risk and the mortality is to be reckoned with, whether due to the operation itself, the anesthesia, or secondary complications.

It has been said that necessity is the mother of invention. When one has suffered from a duodenal ulcer for twelve years and has found no relief in medication or diet, and, at the same time, fears the results of surgical intervention, he will endeavor to find a treatment devoid of risk that promises a fair degree of success, as far as the permanence of the cure is concerned. Therefore, I feel justified in making this preliminary report of a new

therapeutic method for the following reasons: I have secured absolute personal relief from this treatment, and its value has been demonstrated in over 300 additional cases as stated previously; the results being corroborated by the disappearance of symptoms, x-ray examination, and gastric analysis.

For years Holler, Pribram, Mueller and Petersen, and others have been working with various proteins to control gastric functions and check the hypermotility of the stomach. They were able to stimulate the vegetative nerves and produce hypoperistalsis, lessen the amount of free hydrochloric acid, induce a hyperemia and increased vascularity about the ulcerated area in the gastric mucosa, as well as augment the production of gastric enzymes and total lipoids. However, they were able to control these physiological functions only for one and one-half to two hours, which is of little therapeutic value in peptic ulcer.

By reinforcing the protein with lipoids and lipins, a more sustained action was obtained. Finally, it was found that emetine acted as a synergist in such a manner that we were able to control the gastric functions for a period from ninety-six to one hundred and twenty hours with one intravenous injection. The combined solution has also a decided cumulative action so that after the fifth or sixth injection, hypoperistalsis, increased vascularity, muscular relaxation, and dilatation of the stomach are maintained for a period of more than two hundred and forty hours. There is also an increased flow of gastric juice containing a relatively low hydrochloric acid percentage and adequate enzymes. These induced phenomena make the patient comfortable, free from pain, and promote healing of the ulcer. The solution also increases the resistance of the tissues about the ulcer and produces an antibacterial action on the causative microorganisms.

In exhaustive experiments Rosenow has demonstrated that peptic ulcers may be

caused by certain groups of streptococci. He was able to produce ulcers in the stomach of animals experimentally by the injection of cultures from the strains obtained from human gastric ulcers.

A therapeutic agent that will render the patient symptom free and induce healing of a gastric or duodenal ulcer must possess the property of regulating physiologic functions as follows:

Stimulation of the vegetative nerves of the splanchnic plexus must be produced sufficiently to control the gastric motility and regulate the secretory functions of the glands of the mucosa for a period of not less than forty-eight hours.

Hyperperistalsis must be overcome. A constant stretching and relaxation of the tissues about the ulcerated area will not only increase the pain, but will not permit the ulcer to heal.

Severe intermittent, persistent, tetanic spasms of the gastric musculature must be prevented to assure the comfort of the patient.

Hypoperistalsis should be produced to such a degree that the peristaltic wave practically disappears. This is conducive to lessened irritation and rapid healing.

General relaxation of the gastric musculature should be produced as it not only lessens the hypermotility but causes a dilatation of the pylorus, thereby permitting the gastric contents to pass more freely.

The vascularity about the ulcerated area must be increased to enhance the local resistance and promote the reparative process.

Extreme hyperacidity must be lessened either by controlling the function of the acid secreting glands or by relative dilution, which is accomplished by stimulating the secretory function of the prepyloric and cardiac glands. Dilution of the free hydrochloric acid must be carried to such an extent that the gastric contents are only faintly acid or nearly neutral. Free hydrochloric acid not only irritates the ulcerated surfaces, but increases the pain.

Hypoauidity should be produced to such an extent that the amount of free hydrochloric acid is much below normal. The total acidity of the stomach does not need to be considered as the free hydrochloric acid is the agent that produces irritation and delays healing.

There must be an increase of the non-irritating digestive enzymes to facilitate gastric digestion when the stomach is devoid of peristaltic action. This secretion must be sufficient to liquefy the contents of the stomach to such an extent that they will pass through the pylorus with lessened peristaltic movements.

Alkaline secretions and digestive enzymes may be increased from twelve to eighteen times by sufficiently stimulating the vegetative nerves. This can be accomplished, as shown by animal experimentation, with certain proteins.

In addition to regulating physiologic functions as outlined here the agent must destroy or at least inhibit the growth of the infective organism without exerting a toxic action on the normal tissues. Infective foci in the teeth, tonsils, sinuses, etc., should be removed to obtain the results desired.

The surgeon who has observed the abdominal viscera during inhalation, spinal, and splanchnic anesthesia will have noted that under inhalation anesthesia the stomach and intestines are always dilated, over-distended, and that there is no peristalsis. When high spinal or splanchnic anesthesia is employed for non-infective intra-abdominal conditions, there is a normal or increased peristaltic wave, the stomach is small, contracted or collapsed, as also are the intestines. The general belief that gastric dilatation or abdominal distention is due to splanchnic paralysis is a misconception since the arrest of peristalsis is not coincident with splanchnic paralysis, but on the contrary is produced by bacterial or protein stimulation of the splanchnic plexus. This is clearly demonstrated in general or localized peritonitis. The spinal anesthesia is then unable to



overcome the intestinal distention. The action of protein stimulation may also be observed when a blood transfusion is given during an operation under spinal or splanchnic anesthesia. The intestines immediately become distended and peristalsis ceases. The intestinal vessels dilate and a mild hyperemia is observed. The same results may be produced by the injection of certain mild proteins that will not cause a systemic reaction or produce a chill.

Our early experiments were accompanied by such severe reactions that the patients registered innumerable complaints, the principal one being a severe rigor lasting from two to six hours. The proteins injected were obtained from vaccines made from direct streptococci cultures, and later from autogenous serums, none of which could be so developed that they would not produce the anaphylactic symptoms, chill, perspiration, nausea, vomiting in greater or lesser severity, unless given in such minute doses that they were of no therapeutic value.

Animal experiments demonstrated that we could produce the same reaction on the vegetative nerves without causing protein shock. This was a marked contrast to the results experienced when using pathogenic proteins. Certain non-specific proteins were found to cause little or no anaphylactic reaction, such as chill, rise in temperature, nausea, vomiting, perspiration, etc., although experimentally and clinically the desired results were obtained. By combining these non-specific proteins with lipoids, animal fats and emetine, we were enabled to control and prolong the elective action so that it persisted for many hours.

It seems needless to stress the fact that a definite diagnosis is essential in the treatment of gastric ulcers. Even with our modern laboratory methods one is confronted with uncertainties. Therefore, it is advisable to employ gastric analyses, test powders, and roentgenograms in addition to the clinical symptoms to exclude the possibility of cholecystitis with adhesions,

chronic appendicitis, gastric or intestinal polypi, malignancy, gumma, or girdle pains of tabes, etc. We have had 2 cases with typical clinical symptoms of peptic ulcer which could not be satisfactorily demonstrated either by x-ray or gastric analyses. The symptoms were relieved by magnesium oxide (5 grains), sodium bicarbonate (25 grains) and bismuth subcarbonate (30 grains) taken after meals and whenever the pain became severe. From the clinical symptoms and relief obtained by the alkaline powder we assumed that an ulcer existed. Both patients were relieved by intravenous injections of the synergistic solution without other medication, the powders merely being used to confirm the diagnosis. Peptic ulcers may and often do exist without producing symptoms, or the symptoms may occur periodically. Two persons recently treated were totally symptom free during the winter months, but have suffered with gastric distress for four and six years respectively during the summer months. They have attributed their symptoms as due to indigestion from eating berries. The x-ray showed that both of these patients suffered from ulcers.

Clinically, pain is the most prominent symptom of which these patients complain. It may be described as sharp, dull, boring, burning, constant or intermittent. It may be so slight that it is described as a passing twinge, or so severe as to require opiates. It may appear immediately after eating, but usually is more intense from two to four hours after the ingestion of food. When the pain occurs two or three hours after a meal it may usually be relieved by a glass of milk, light food, or the administration of some alkaline powder, as either food or alkali medication reduces the degree of acidity. The pain is largely influenced by the character of the food. Bland articles such as milk, eggs, cereals, broths, custards, jellies, etc., are less apt to produce distress than are highly seasoned and heavy dishes. Alcoholic beverages invariably increase the gastric distress and often so irritate the ulcerated surface that pain does not disap-

pear for days and weeks. The number of peptic ulcers seen in European hospitals is striking as compared to those observed in

respiratory and digestive tracts can be excluded. The presence of blood in the stools should be considered suggestive of a



FIG. 1. Stomach of Mrs. A. W., at time treatment was started, showing well defined ulcer. Hypermotility.



FIG. 2. Stomach of Mrs. A. W., two months later, ulcer not visible, duodenum dilated. Hypomotility.

America. Possibly this is due to the highly seasoned, greasy foods customary to the continent. It may be attributed to the free indulgence of alcohol or possibly is caused by the very bad oral hygienic conditions, which exist among the poorer classes.

Observing the action of alkalies, Sippy recommended magnesia, bismuth and sodium bicarbonate to differentiate the pain caused by an ulcer from other pain producing pathologic conditions of the stomach or duodenum. Vomiting may or may not be considered as a diagnostic symptom. It probably occurs more frequently in pyloric than in gastric ulcers. When vomiting occurs the pain is invariably relieved. Should blood be present in the vomitus, either as a faint trace or as a moderate hemorrhage, it is of considerable diagnostic value, provided that bleeding from the gums, nose or other parts of the

gastric or duodenal ulcer. Unfortunately in these cases we have no characteristic clinical syndrome by which we are able to make a definite diagnosis of either gastric or duodenal ulcer, as jejunal polypi may produce similar symptoms that are quite impossible to differentiate clinically.

Unquestionably the x-ray is one of our most valuable aids in diagnosis. The presence of a duodenal ulcer is demonstrated positively by this means in almost every case, be it by actual view of the barium-filled crater, or constant deformity of the cap; indirect signs, such as hypermotility and increased tone of the stomach point to duodenal ulceration, but are merely confirmatory. Gastric ulcer, however, though demonstrable in many cases by the use of the opaque meal and the x-ray is unfortunately not to be diagnosed with any comparable degree of certainty. Posi-

tive diagnosis, where an ulcer crater fills and shows on the fluoroscopic screen or skiagraph, is beyond question; but a

taken before and after treatment, together with the accompanying histories. Some of these cases were hospitalized, others were



FIG. 3. Marked lesion of duodenum August 28.



FIG. 4. Duodenum has assumed appearance approaching normal.

negative diagnosis is far from absolute, as a small ulcer or one confined to the mucous membrane may be missed. The "crossbar" sign of Fraenkel, where a peristaltic wave advances as far as the lesion, fades out, then reappears distally to pass onward to the pylorus, never passing through the site of the ulcer, is strongly suggestive. The roentgenologist may deduce from the alterations in the gastric motility and emptying time, that an ulcer is present, but his conclusions are, at best, only inferential. Again, x-ray examination is unable to reveal the onset of malignant change in a previously benign ulcer.

We must, therefore, resort to a combination of diagnostic aids in numerous cases before a definite diagnosis may be obtained with reasonable certainty.

As it is impossible to include in this article all of the results obtained in this preliminary series treated with the synergistic solution we will illustrate some of the more striking cases with skiagraphs

ambulatory, and needless to say those selected for demonstration here, were among the most severe of the series. The lesions were the most pronounced and so marked that they are clearly demonstrable. The dates on the skiagraphs show the results obtained in a comparatively short time. These patients, as well as the others treated, are at the present time symptom free.

**CASE 1 (Private Office).** Mrs. A. W., an American housewife, aged thirty-one, was referred for diagnosis and treatment September 11, 1930.

The *family history* was essentially negative.

*Previous history and present condition:* The woman had been having stomach trouble for six years. In April, 1926, while in a department store, she had a severe gastric hemorrhage, fainted, and was removed unconscious to a hospital. Here she remained under treatment for two weeks and was then permitted to go home. She continued under medical supervision for several months. The epigastric pain became aggravated by indiscretions in diet,

the painful attacks usually continuing for periods of two or three weeks. At the time of the hemorrhage she weighed 134 lb., but was



FIG. 5. Ulcer in case of Mr. MacN. clearly demonstrable. Note barium elevating peritoneum.

never able to increase her weight above 126 lb. thereafter.

Six months before she came under the author's observation she had another (slight) hemorrhage, after which the pain had been almost continuous. During the latter part of August she had a moderately severe emesis; according to her statement the vomitus contained bright red blood and a black substance that looked like coagulated blood. She had rarely vomited at other times. There was no clear history of tarry stools.

At the time of examination, she complained of severe pain at the costal arch, which was most intense in the middle of the forenoon, the middle of the afternoon, and during the night. She had to get up several times at night to take milk or sodium bicarbonate, which gave relief for one or two hours. She stated that the pain radiated to the left side along the border of the ribs.

*Physical examination:* The abdomen was symmetrical, scaphoid. Upon palpation, tenderness was elicited below the ensiform, almost in

the midline. Percussion disclosed the lower border of the stomach at the umbilicus. There were no areas of rigidity, pain or tenderness in the lower abdomen. Vaginal and other physical examinations yielded negative findings. Temperature 98.4°F.; pulse 108; respiration 36. Hemoglobin 60; erythrocytes 3,600,000; leucocytes 11,200 (polynuclears 48, small lymphocytes 46, transitionals 5, basophiles 1). Blood pressure 110-62. Urine alkaline; specific gravity 1.010; no albumin; no sugar; acetone plus; no indican; a few pus cells and epithelial cells.

A provisional diagnosis of peptic ulcer was made from the previous history. An intravenous injection of the synergistic solution was given. At this time roentgenologic examination of the gastrointestinal tract was advised. Upon completion of the serial roentgenograms, September 14, the diagnosis of penetrating preduodenal ulcer was confirmed (Fig. 1). Somewhat less than two months later, the ulcer had apparently disappeared (Fig. 2).

The patient experienced no pain or digestive disturbance after the first injection, and has been free from symptoms since. At the present time she is not subjected to any restrictions in diet, with the exception of alcoholic beverages.

**CASE 11.** No. 13279, Mr. L. J., a Jewish salesman, aged fifty-two, entered the hospital August 26, 1930, referred for gastroenterostomy by his nephew, a physician. The family history was negative.

*Previous history and present condition:* He was perfectly well until 1927 when he first complained of epigastric pain, which became very intense about one and a half hours after meals, he was nauseated between meals, had gas and belching, and lost weight progressively. Entered Mt. Sinai Hospital, New York City, where a diagnosis of duodenal ulcer was made, and confirmed by x-ray. He remained in the hospital five weeks on medical and dietary treatment. After being discharged he conscientiously adhered to medical treatment and diet, but grew progressively worse. He returned to the hospital in 1928 and 1929, each time remaining for six weeks. At first he had pain over the whole upper abdomen, beginning about one and half hours after meals. This relief interval gradually shortened until the pains began about a half hour after meals and persisted until he ate something. To have any degree of relief it was necessary for him to take

food about every hour. The pain had been most persistent at night, and in the last eight months so severe that he could not sleep. For two years he had been unable to work. He had spells of nausea several times a day and vomited two or three times a week. The vomitus contained no blood.

*Physical examination:* Definite tenderness over the entire epigastrium was elicited. There was no rigidity or palpable mass or distention. He had many decayed teeth and marked pyorrhea. No other pathologic signs were demonstrable with the exception of hypertrophy of the left ventricle. Erythrocytes 4,600,000, leucocytes 7200 (polynuclears 58, small lymphocytes 38, transitionals 4) hemoglobin 80. Urine analysis and Wassermann reaction were negative. Weight 124½ lb. (in 1927 it was 174 lb.).

Serial roentgenograms confirmed the diagnosis of duodenal ulcer. Permission was obtained to try the synergistic solution before resorting to surgery. Eight injections were given at three-day intervals. After the third injection the patient was free from pain. Four weeks after the first injection, he was permitted to eat meats, fruits and vegetables. On October 26, the weight had increased to 145 lb. The patient is still on a full diet and is symptom free (Figs. 3 and 4).

**CASE III.** No. 12895. Mr. MacN., an American salesman, aged thirty-two, entered the hospital July 10, 1930 for diagnosis and treatment.

The *family history* was negative.

*Previous history and present condition:* He had indigestion for over a year, partially relieved by diet and medication, but severe if medicine was discontinued or the diet not strictly adhered to. The stomach distress was most intense about one hour before meals and was relieved by food. For four weeks he had been gradually losing weight and strength. Indigestion had been worse, and there were frequent dizzy spells and headaches. There was no vomiting. The stools had been black.

*Physical examination:* The patient, 5 ft. 11 in. in height, weighed only 135 lb. but nutrition was fair. The abdomen was pale and scaphoid, the musculature not well developed. There were slight tenderness and rigidity in the mid-epigastrium, most severe just below and to left of ensiform. The pain did not radiate. There were no palpable masses. The liver and spleen

were not palpable and there were no enlarged glands.

Temperature 99°F., pulse 96; respiration 20.



FIG. 6. Change that has taken place in less than three months.

Blood pressure 120-76. Erythrocytes 1,880,000, leucocytes 9800 (polynuclears 72, small lymphocytes 26, eosinophiles 1, transitionals 1, many poikilocytes, few macrocytes and microcytes): hemoglobin 36, type 4; coagulation time three minutes, stools blood 4 plus. July 12, 1930, blood pressure 105-70. Erythrocytes 1,660,000, hemoglobin 30. Serial roentgenograms demonstrated the presence of a perforating gastric ulcer (Fig. 5). Urine was alkaline; specific gravity 1.012; no albumin, sugar, acetone or indican. At this time the patient was given 6 c.c. of synergistic solution intravenously, repeated on the third, sixth, ninth, twelfth and fifteenth days. July 13, 1930, the patient was comfortable, had no epigastric pain and suffered no indigestion. July 21, 1930, erythrocytes 2,800,000; hemoglobin 43; stools negative for blood. July 30, 1930, blood pressure 120-80. Erythrocytes 2,920,000; hemoglobin 44; stools negative for blood. The patient was discharged on July 30 and returned to work on September 1 with no pain or indigestion, weighing 154 lb. September 22 the patient was absolutely

symptom free, erythrocytes 4,110,000, hemoglobin 62, the ulcer apparently healed (see Fig. 6).

oz., and a greater quantity of liquid would regurgitate. X-ray examination taken on June 14 showed almost complete obstruction of the

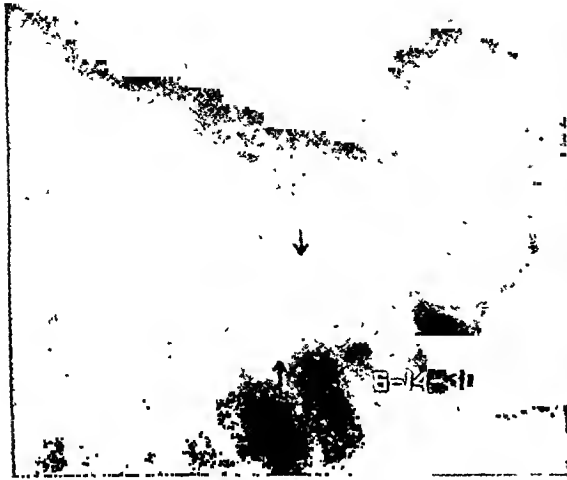


FIG. 7. Stomach and duodenum of P. W. M. before treatment was started. Marked stenosis of pylorus and contracture of stomach as described in history.



FIG. 8. Results obtained in P. W. M.'s case after three and a half months' treatment. Compare size of two stomachs.

CASE IV. Dr. P. W. M. an American physician, aged forty-five.

*Family history* negative.

*Previous history and present condition:* In 1918 he began to have periodical attacks of epigastric pain, some belching of gas and regurgitation of food. These attacks, lasting for one to three weeks, were rather mild, but gradually increased in severity. In 1920 the pain was sometimes so severe that codeine was required for relief. It was aggravated by acid fruits or alcoholic beverages. In 1924 severe periodical attacks of pain were accompanied by vomiting (no blood). A New York gastrologist made a diagnosis of duodenal ulcer on x-ray findings, and prescribed a strict diet and an alkaline powder, which gave relief for some time. Indiscretions of diet caused the symptoms to return. By 1926 the hunger pains became so severe that he was forced to carry a thermos bottle of milk and egg with him on his rounds, as well as to bed; every night he consumed from a pint to a quart of this mixture. He habitually pressed his hand over the pit of his stomach, as the pressure brought relief. During this interval dietary and alkaline medication had been followed at various times for two to six months. Previous to June 1930 he had been unable to eat solid food, subsisting solely on milk, milk and egg mixtures and broths. The capacity of the stomach was 7

pylorus (Fig. 7) with marked contracture of the stomach.

*Physical examination:* The patient, 5 ft. 7 in. in height, weighed 142 lb.; nutrition was fair. Blood pressure 123-66. The abdomen was tender on deep pressure to the right of the midline, but light pressure was comforting. The liver and spleen were not enlarged. Genitourinary organs were negative. Urine was acid, specific gravity 1016; no albumin, sugar, or acetone; indican 2 plus. Feces negative for blood. Erythrocytes 4,620,000, leucocytes 9300, hemoglobin 75, (polynuclears 74). A diagnosis of pyloric ulcer with stenosis was made. From June 14 until July 10 the patient had eight injections of the synergistic solution intravenously at three-day intervals. He was completely relieved of pain after the second injection. On July 19, 1930, the patient attended a testimonial dinner and ate various foods without suffering distress. On July 24, he went on an extended trip during which he ate all kinds of food without discretion and resumed

his habit of drinking six to ten cups of coffee a day. He indulged moderately in beer, wines and liquors without distress. He has had no

examination of the vomitus) was 55. The vomitus and stools both contained blood. X-ray examination and intragastric photog-



FIG. 9. Lesion in stomach of Mr. J. T. clearly visible as indicated by arrow.

pain or recurrence of old symptoms since the second injection. He has gained weight, and is able to eat a hearty meal. On September 30, the x-ray examination showed that the stomach was increased in size (Fig. 8). The duodenal lesion had apparently disappeared.

**CASE V.** Mr. J. T., an American printer, aged forty.

*Family history* was essentially negative.

*Previous history and present condition:* The patient had been a moderate drinker for a number of years, always taking two or three drinks on the way home from work, occasionally a drink in the morning. He indulged in periodical sprees. In October 1929, he weighed 137 lb., but at the time of admission only 113 lb. For the past two and a half months he had been treated for pain localized under the costal margin, which was not aggravated or relieved by eating, but was allayed for one and a half to two hours by powders he was taking. There was no discomfort at night. On June 29, 1930, he had a number of drinks with a friend. At night he vomited a few times, the vomiting persisted with increased frequency after that time. The day before admission he vomited about 2 qt. of a dark brown material.

*Physical examination* was negative except for an extreme tenderness just below the ensiform and along the left costal margin. The free hydrochloric acid content of the stomach (from



FIG. 10. Note appearance of lesser curvature of stomach where lesion has disappeared.

raphy demonstrated a perforating ulcer of the lesser curvature (Fig. 9). On July 7, 1930, he was given 6 c.c. of the synergistic solution intravenously. This rapidly curtailed the vomiting and lessened the pain. On July 9, 1930, a second injection was given and on the next morning, the patient had no pain. The intravenous injections were continued at three-day intervals until July 24. On his return, September 24, 1930, the x-ray examination (Fig. 10) showed the ulcer completely healed. His weight was 143 lb., more than it had ever been.

**CASE VI.** Mr. M. C. Q., a publisher, operated upon 1928 for ruptured duodenal ulcer. Pain persistent until May, 1930, at which time he was given six injections. Pain was relieved after second injection and to date is symptom free.

**CASE VII.** Mr. M. C., a carpenter, heavy drinker, operated upon twenty hours after rupture of duodenal ulcer. Eleven days after operation complained of severe pain. The injections were started. Pain was relieved after first injection, to date is symptom free.

The other patients with repaired ruptured duodenal ulcers were started on treatment the day following the operation. None of them complained of pain and have been symptom free.

**CASE VIII.** Mr. J. M. was subjected to



gastroenterostomy in 1927. The pain persisted to 1930, but was relieved after the first injection. Ten injections were given in all.

CASE IX. Mr. T. P., gastroenterostomy, German Hospital, New York, 1914. Pain persisted until 1930; was completely relieved after six injections. Gain of 30 lb. in weight.

CASE X. Mr. J. L., operated on in 1924. No relief from pain. Pain ceased after second injection; symptom free.

CASE XI. Mr. H. A., gastroenterostomy in 1927. Pain persisted. Eight injections; symptom free.

CASE XII. Mr. E. T., gastroenterostomy in 1927. Pain persisted. Six treatments; no relief. Refused x-ray examination.

CASE XIII. Mrs. A. S., gastroenterostomy in 1927. Pain persisted. Marginal ulcer excised in 1928. In April, 1930, severe gastric hemorrhage; transfusion. Eight treatments; symptom free since first injection.

In the hemorrhagic cases, intravenous therapy was given every second day. The vomiting ceased immediately in the 3 cases treated. The stools were negative for blood in three to five days.

The appendix and gall-bladder patients who had previously been operated upon for pain all had demonstrable duodenal lesions. These cases are of interest because the diagnosis was not completed at the time of operation.

A chronic appendix may have been removed without discovery of the ulcer, or the ulcer may have been the primary cause of pain, the appendix the innocent aggressor. The same may be said in regard to the gall-bladder cases.

CASE XIV. Mr. A. B., operated upon in 1924 at Harlem Hospital for adhesions about the duodenum and gall bladder. Two weeks after he had gone home, he had a severe gastric hemorrhage and returned to the hospital where he remained three weeks for treatment. Pain persisted until 1930. Relieved after first treatment. No recurrence of pain.

One of the gastropexy patients was completely relieved of pain. Two com-

plained of heavy feeling after the series of treatment. A belt was applied in all cases.

The patient with syphilitic ulcer received no relief. He is now on antisyphilitic treatment.

The results in penetrating gastric ulcers are shown in the preceding cases.

In the cases of penetrating duodenal ulcers the follow-up x-ray examinations were not made.

The case histories and x-ray prints presented here have been selected because the lesions as well as the end-results are clearly demonstrable.

The technique of administering the synergistic solution is no more difficult than any intravenous medication. Apparently better results are obtained by using a fine 25 gauge needle and a 3 ring control syringe. A fine 25 gauge needle produces much less pain than does the larger 21 or 22 needle, so frequently used for intravenous work. The 3 ring control syringe permits of aspiration, assuring the operator that he is in the vein, and injection of the solution without changing the position of the hands. This obviates the possibility of the needle's slipping out of the vein or possibly perforating the inner wall. If for any reason the median basilic or median cephalic cannot be utilized the solution may be injected intramuscularly into the arm or the buttocks. If the intramuscular method is employed the patients may complain of some pain at the site of injection, but the discomfort is no greater than that produced by an ordinary hypodermic. It is inadvisable to inject the solution subcutaneously. If injected intradermally it produces a rather severe local reaction which may last for a week or ten days. As a routine the injections may be given twice a week or every third day. If the ulcer is producing intense pain or is bleeding the solution may be given daily or every second day until the symptoms are relieved.

It is preferable to inject the solution when the stomach is empty as the reaction is almost immediate, and if it is given



after meals vomiting may occur, not of the projectile type but a spontaneous emesis due to the relaxation of the cardia. Not infrequently after the intravenous injection, the patient complains of feeling a little light headed or possibly nauseated. This usually can be controlled by asking him to take a few deep breaths. Should the patient be dehydrated or have acidosis a dram of bicarbonate of soda given five or ten minutes before the medication usually prevents nausea or vomiting. Dizziness, nausea or vomiting rarely occur when the injection is given to patients in bed, but the reaction is so slight and occurs so rarely that it is not necessary to place the patient in a prone position. The milder cases are invariably free from pain after the first injection, but the severe ones or those with more chronic lesions are not as a rule completely relieved until after the third and sometimes the fourth injection. Six injections at intervals of three or four days usually suffice in the milder cases. Patients who have suffered for a long time or those with marked gastric or duodenal lesions may require eight doses. The maximum number of injections for one course is ten. If a second course of treatment is required, six to eight weeks should intervene.

It is essential that bland foods be given during the treatment. The diet need not be as restricted as the ordinary gastric ulcer diets or the Sippy diet. For the first week or ten days if hunger pains are troublesome, milk or milk and egg should be given at 10 A.M., 3 P.M. and 9 P.M. As soon as the pain has disappeared the food between meals may be stopped. The following diet has been given to patients for the first three weeks: Milk, cream, butter-milk, malted milk, ovaltine, coco-malt, milk and egg, soft eggs (not fried), bouillon, beef broth, veal broth, mutton broth, chicken broth, rice, barley, potato and celery soups, well cooked rice, farina, gruels, cream of wheat (no oatmeal), corn-starch custards, rice pudding, bread pudding, baked or mashed potatoes, plain

vanilla or chocolate ice-cream, ices and plain sponge cake.

Tea, coffee and alcoholic beverages must be eliminated.

After the third week fish baked, broiled or boiled (not fried), white meat of chicken, peas, squash, spinach, mashed carrots, asparagus, fruit juices and stewed fruits, with the exception of berries. After the fifth week the diet is unrestricted with the exception of alcoholic beverages, preserved meats or fish.

Who is to determine whether a gastric or duodenal ulcer shall be treated medically or surgically. The internist usually attempts medicinal cure, and will not permit the patient to undergo surgical intervention except as a last resort. The majority of surgeons look upon these lesions as a surgical condition. In an article recently published, the Sippy diet was reported to have cured 49 per cent of all gastric and duodenal ulcers. If conclusions may be drawn from the small series here offered, apparently a greater number of cases are rendered symptom free by this method. At any rate, before radical surgery is considered, it is deserving of a thorough trial with the hope that the symptoms may be overcome without subjecting the patient to the dangers that often accompany a subtotal resection or gastroenterostomy. What percentage of cures can surgery actually demonstrate? This is very hard to estimate, there is such a large variation in statistics from different clinics.

The series of cases that are reported here is far too small from which to draw final conclusions. Possibly, enthusiasm has made us somewhat optimistic. We have discontinued other methods of treatment because the great majority of our patients are symptom free within three to six days. By the use of roentgenography it has been possible in from ten to twelve weeks to demonstrate in many of the gastric ulcer cases the healed lesion as well as a lessened deformity of the pylorus. The symptoms of obstruction both objective, and subjec-

tive, disappear and, although we cannot demonstrate a normal duodenum by fluoroscopy or roentgenography, there is a relaxation of the constricted area in practically all cases. One feels justified in reporting such findings. The patient is not

compelled to discontinue his usual vocation. He does not lose time, does not have to be hospitalized and can be permitted a fairly liberal diet.

Time will demonstrate the end-results. At a future date these will be published.

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# RECURRENT TORSION OF THE SPERMATIC CORD\*

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**S**TRANGULATION of the testis due to torsion of the spermatic cord is a well-recognized condition, though the individual practitioner meets it infrequently. There are 135 cases reported in the literature, the first of which appeared in 1840, but there is reason to believe that the condition is more common than this would indicate, and that it is often unrecognized. It occurs in all decades from infancy to old age, though most commonly about the age of puberty and in early adult life.

The predisposing cause of torsion seems to be some abnormality of development, for incomplete descent was present in over half of the recorded cases, among which are 7 cases of torsion of intra-abdominal testes.

Etiological factors which have been suggested are

1. An unusually loose scrotum
2. A voluminous tunica vaginalis
3. An unusually long gubernaculum
4. An abnormal attachment of the cord to the testis.

Of these, the last two seem to be the most important, and it is easy to see how they might be associated with incomplete descent which is only one aspect of faulty development.

Ordinarily the reflection of the parietal layer of the tunica over the epididymis forms a mesentery (mesorchium) running from the globus minor to about the middle of the globus major. In most of the recorded cases of torsion, where the pathology has been noted, this mesentery has been much shortened, including only the globus major. The testis is suspended near the lower end of a "cable" consisting of the cord and the gubernaculum. Ordinarily when the mesentery described here is broad, and the gubernaculum short, a twist

of the testis along the axis of this cable would be difficult to produce. But if the mesentery is narrow and the gubernaculum long, the testis is attached by a narrow band to the cable, and farther from the fixed lower end of it than normally, and it is easy to conceive of rotation, either around the axis of the cord and gubernaculum, or of the testis and its mesentery on the cord.

The first effect of this rotation is flattening of the veins and partial obstruction of the venous return; then as the rotation continues there occurs successively, obliteration of the veins, partial obstruction of the artery, and finally obliteration of the artery.

The effect on the testicular mass depends on the degree of torsion. If the venous return is not completely obstructed there will be congestion and edema, especially of the epididymis, which is more distensible than the testis. If the venous return is entirely obstructed, the congestion is greater and necrosis occurs in a short time. Of course, if the twist is sufficient to obliterate the artery, infarction occurs.

In some cases, operation has shown this pathological condition in patients having attacks like torsion but no torsion found. Probably spontaneous detorsion had taken place after necrosis had occurred. If detorsion is brought about soon enough, necrosis may be prevented, but even so, some degree of atrophy may result. It can be seen that repeated torsions, even when not extensive enough to cause complete blockage of the veins, by causing repeated congestion, might eventuate in atrophy.

The majority of the atrophic testes which we see are undoubtedly due to mumps; but it is probable that torsion is responsible for a certain proportion, either acute complete torsion or the incom-

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plete possibly recurrent type, unrecognized as such and wrongly diagnosed as epididymitis. In these latter cases, had the true condition been recognized and proper measures taken, atrophy might have been prevented.

Most of the cases reported in the literature are those of complete strangulation with resulting gangrene. Since the symptoms are quite severe, operation has usually been performed and orchidectomy has been the rule. In a few cases detorsion has been possible when seen early, and there are a few cases of repeated attacks of incomplete torsion, and fewer still of incomplete torsion occurring over a fairly long time, and treated repeatedly by detorsion.

The following case is deemed worthy of report as illustrative of the condition last mentioned, and because it presents some very unusual features. These cases are rare, but may occur more commonly than they are recognized, and their recognition may prevent a few cases of testicular atrophy.

#### CASE REPORT

Dr. R. M., physician, interne at the Henry Ford Hospital, aged twenty-seven, married, was seen in the spring of 1929, complaining of a sudden attack of epididymitis, left. He gave a history of recurrences of this condition for twelve years, and had consulted urologists in various cities, being given diagnoses of tuberculous epididymitis, traumatic epididymitis, etc. There was no history of venereal disease; no fever or leucocytosis in attacks; the onset was usually sudden and recovery after a day or two equally rapid and always complete, no induration of the epididymis persisting.

Examination showed as follows:

Well-developed white adult.

Height 5 ft. 5½ in.

Weight 132 lb.

Temperature 98.6, pulse 80, respiration 18.

Pupils reacted to light and accommodation.

Tonsils had been removed, otherwise there was nothing unusual in nose and throat.

No general glandular enlargement.

Lungs clear to auscultation and percussion.

Heart not enlarged, no murmurs.

Blood pressure 120/80.

Abdomen showed no masses or tenderness.

No abnormality noted in extremities—deep reflexes normally obtained.

Prostate and seminal vesicles normal to palpation.

Urine—not remarkable.

The scrotum showed no edema. The left testis was a little larger than the right, rather tender, and the epididymis was enlarged—not indurated, and very tender. It lay in its normal position as regards the testicle. The testicular mass was too tender to permit much examination.

He was sent home to rest, and the next day reported back to work, the testis and epididymis showing no signs of any disturbance.

He was seen in two similar attacks before the true diagnosis was made, and detorsion attempted successfully by the patient himself. Since then he has had numerous attacks, relieved immediately by detorsion. Operation is advisable, and the patient expects to have this done, but has not yet found it convenient. He has been examined several times in intervals between attacks. The left testicle is possibly a trifle smaller than the right, but its consistency seems the same as the right. The globus minor cannot be felt. Near the upper pole the globus major is palpable, but apparently is a little above the testis. It is evident that very little atrophy has taken place and that the attachment of the epididymis to the testis is abnormal. Descent seems complete. He reports that in the attacks there is always one complete twist clockwise. Recently in performing detorsion he has had to rotate the testis end over end as well as counter clockwise.

The following is an account and description of his attacks written by the patient himself:

Date	Attack	Relieved by
Summer 1917	First attack following a fall on a bicycle.	Rest and cold compresses to scrotum.
Fall 1917	Attack following exercise.	Sleep and cold compresses to scrotum.
Spring 1918	Following lifting of heavy weights.	Sleep
Summer 1920	Several attacks, always associated with mountain climbing (when suspensory was not worn).	Sleep and relaxation.
1921-1922	One or two attacks. Details not clear.	
Fall 1923	Two attacks. No apparent cause.	Sleep and rest.
Sept. 1925	Severe attack, following pushing a car from a ditch.	Sleep and relaxation.
July 1926	Attack, no apparent cause.	Rest and relaxation.

Date	Attack	Relieved by
July 1927	Severe attack, following pushing car from ditch	Morphine, sleep and rest.
Jan. 1928	Attack, no apparent cause.	Sleep and cold compresses to scrotum.
March 1928	Attack, no apparent cause.	Morphine, sleep and rest.
July 1928	Attack, no apparent cause.	Rest in bed.
Jan. 1929	Attack, no apparent cause.	Rest in bed and sleep.
March 1929	Attack, no apparent cause.	Hot bath, rest and sleep.
April 1929	Attack, no apparent cause.	Hot bath, rest and sleep.
May & June 1929	Three attacks, two of which have been successfully relieved by untwisting of the left testicle	

### CHARACTERISTICS OF ATTACKS

Pain is always limited to the left testicle, and is always of the same character with each attack, i.e., severe constant pressure type of pain which does not radiate.

Scrotum does not swell or become edematous, but the left testicle becomes hard and swollen, filling the scrotum. The epididymis becomes swollen and very tender.

No abdominal pain or tenderness associated with attacks, and no fever or leucocytosis observed.

Attacks have been coming more frequently of late, but are of a less severe degree.

From June, 1929 to June, 1930, untwisted many times.

One complete twist clockwise present always. More recently has had to rotate it end over end.

Only very slight atrophy if any.

### DISCUSSION

The diagnosis of this condition presents some difficulties, especially in the first attack or when the patient is seen in one attack only. Probably the most important diagnostic point is the position of the epididymis. Normally the epididymis lies posterior and medial to the testis. In case of torsion, if the twist is through  $360^\circ$  or any multiple of it, the epididymis will lie in the normal position, otherwise not. This applies to acute complete as well as to the incomplete and recurrent types. In the complete type it is sometimes difficult to recognize the epididymis on account of the swelling and tenderness of the whole testicular mass. In the attacks of recurrent torsion, the obstruction to circulation is not complete and, as in the case here reported, the swelling may be largely confined to the

epididymis, making recognition of its position rather easy.

The history gives another important lead to the diagnosis. A history of repeated attacks with rather sudden onset and rapid recovery with no apparent residual induration of the epididymis is almost diagnostic, particularly if the affected testis is a little smaller than the other. The absence of previous venereal disease may be important and the lack of fever, leucocytosis or pathological urinary findings may also be of assistance, as well as the finding of seminal vesicles normal to palpation.

A correct diagnosis is important, for on it the health of the affected testis depends. Undoubtedly repeated occurrences of congestion and ischemia will eventually result in some degree of atrophy, and there is always the possibility that in any one attack the obstruction may become complete and infarction result. If the diagnosis be made, the testis may be rotated so as to untwist the cord and thus relieve the situation for the nonce. Nevertheless some operative procedure for the prevention of future twists should be undertaken as soon as convenient.

An interesting point in connection with torsion is that on the left the twist is usually clockwise, and on the right counter clockwise, and this might be remembered if an attempt be made to untwist.

The predisposing causes have been discussed. The exciting causes are many: almost any kind of trauma affecting the cord or testis, almost any kind of muscular exertion, and in many cases no exciting causes were evident. It will be noted that in the case reported, some kind of unusual exertion seemed to be the commonest exciting cause.

A few cases similar to this one have been reported, and probably many have gone unrecognized. Dowden, in 1905, in reporting a few cases, introduced his paper with the following paragraph:

"Torsion of the spermatic cord occurs with greater frequency than is generally

supposed, and the reason why it is not more often recognized is due to the absence or scant information in most surgical text books . . . With regard to recurring tor-

sion of the cord, there is very little information."

This statement is almost as applicable today as it was when it was written.

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\* Continued from p. 509.

# ANNULAR PANCREAS

## ASSOCIATED WITH PEPTIC ULCER\*

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**D**URING the past year the author<sup>1</sup> reported the twenty-ninth case of annular pancreas in the medical literature. Since then Howard<sup>2</sup> reported an additional case bringing the total of previously reported cases up to 30. In spite of the fact that Howard missed several cases in reviewing the literature, his article is highly recommended to the reader for the fine drawings illustrating the embryology of the pancreas and the possible explanation of the embryological defect.

The 2 cases observed by the author were found in the routine prosection at about 2500 necropsies, in 1468 of which especially attention was given to anomalies of the pancreas. In the first case acute hemorrhagic pancreatitis was present in the main and annular portion of the pancreas, a combination which probably has not been otherwise observed. The report of the author's second case and the thirty-first case reported in the literature is as follows:

The patient was a forty-four year old English laborer who was admitted to the Receiving Hospital on May 13, 1930, complaining of epigastric pain, belching of gas and vomiting. The first two of these symptoms began three years before. The pain occurred from ninety to one hundred twenty minutes after the intake of food and was relieved by either milk or solid food. In the last year the pain became more severe and he vomited occasionally. He had twice been a patient in another hospital, in August, 1929, and April, 1930, where a diagnosis of peptic ulcer was made. His condition became progressively worse on medical treatment; he had lost weight and had become very weak. He had not had

diarrhea or blood in the stools. The history by systems was otherwise unimportant.

The physical examination revealed a white

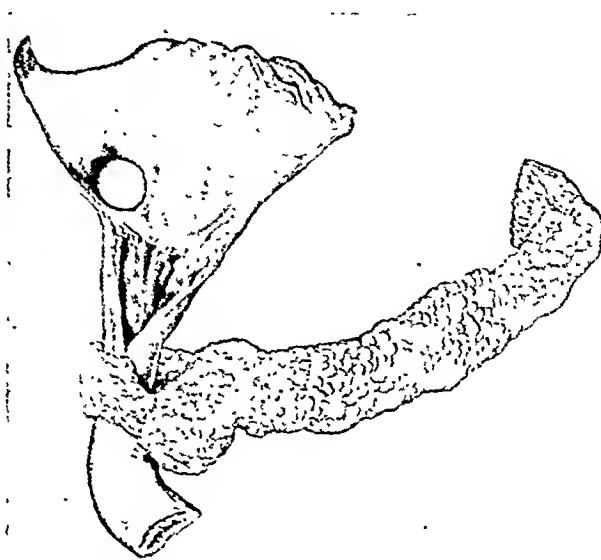


FIG. 1. Annular pancreas associated with chronic peptic ulcer.

male adult who was somewhat emaciated but did not appear acutely ill. The epigastric region was tender to moderate pressure but there was no spasticity or palpable tumor.

The radiographic examination showed a large dilated stomach with hyperperistalsis emptying through a persistently deformed bulb. At the end of six hours there was 60 per cent retention and 30 per cent in twenty-four hours. The laboratory findings were unimportant except for a 4-2-1-0-0 Kolmer test and a 2 plus Kahn.

With a preoperative diagnosis of stenosing duodenal ulcer a gastroenterostomy was performed under spinal anesthesia on May 27, 1930; a chronic ulcer, the crater of which was 12 mm. in diameter, was found on the lesser curvature. Following operation he developed a respiratory infection with an accumulation of fluid in the right pleural cavity and on June 12, 1930, the sixteenth postoperative day, he expired.

At autopsy bilateral acute fibrinopurulent

<sup>1</sup> Brines, O. A. Annular pancreas involved in acute hemorrhagic pancreatitis. *Ann. Surg.*, 92: 241, 1930.

<sup>2</sup> Howard, N. J. Annular pancreas. *Surg. Gynec. Obst.*, 50: 533, 1930.

\* Submitted for publication December 23, 1930.

pleurisy and pericarditis with pleural and pericardial effusion was found. The right pleural cavity was filled with thin purulent fluid which collapsed the lung against the mediastinum. The left pleural cavity was one-third filled with less turbid fluid and the pericardial sac contained 100 c.c. of the same material. An old ulcer 22 mm. was found on the lesser curvature of the stomach. The distance from the nearest edge to the pyloric ring was 15 mm. The duodenum was completely encircled and slightly constricted by a ring of pancreatic tissue which connected posteriorly with the head of the pancreas and anteriorly with the uncinate process. The inner diameter of the ring was 22 mm., its thickness 6 mm. and its width from 15 to 22 mm., the narrowest portion being the anterior aspect and the widest portion to the right of the duodenum where one would expect it to be narrowest. The anastomosis of the stomach and jejunum was properly in place and healing had progressed normally.

#### SUMMARY AND CONCLUSIONS

1. An additional case of annular pancreas is reported bringing the total of reported cases up to 31.
2. In this case annular pancreas and gastric ulcer was present together, the combined clinical and radiographic evidence pointing to a stenosing duodenal ulcer.
3. Had this patient recovered, symptoms of partial obstruction would probably have persisted because surgical attention was not directed to the annular pancreas.
4. Failure of the surgeon to appreciate the full importance of the pathology present was doubtless due to the rareness of the condition.
5. The few cases in the literature probably do not reflect the true incidence of the condition and the author hopes that by directing attention to it more cases will be recognized and that in the future annular pancreas will receive its proper place as a pathological and surgical entity.





# REMOVAL OF PEDUNCULATED GROWTHS

## OF THE SIGMOID AND UPPER RECTUM\*

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CERTAIN types of pedunculated growths such as adenomata and fibromata are found in the upper rectum and sigmoid occasionally. They require surgery because they are prone to bleed and may be starting points of the carcinomata found in this region. Of course such tumors may be excised by the abdominal route, but as this involves enterotomy and suture of the gut it carries the usual risk of such a procedure. Removal from below is free from this objection and may be carried out in growths situated a considerable distance from the anus. In a recent case the writer succeeded in excising by this method a border-line adenoma the size of a large strawberry 10 in. from the anal margin. However, in operations through the rectum certain points should be borne in mind and these will be discussed here.

### PRACTICAL CONSIDERATIONS

The first one is good illumination through an operating sigmoidoscope of proper length and diameter, as it is risky to work in poor light. The writer uses an electric instrument of special make 12 in. long and  $1\frac{1}{4}$  in. wide which may be connected through a rheostat to any standard electrical fixture. But it is not essential to have this, as a head mirror with a 15 Watt lamp will do, if one is accustomed to that kind of light. An instrument of this size will not pass the rectosigmoid junction except under anesthesia because of a narrowing of the bowel at this point by a thickening of the circular muscular fibers (O'Beirne's sphincter), and regional block seems especially suitable here by reason of its property of inducing a most complete relaxation. For pedunculated tumors of the posterior wall of the rectum or dorsal aspect of the

gut the knee-chest position is desirable because those so located will be displaced by gravity, fall downward and become easily visible and readily accessible. But as under spinal anesthesia the patient cannot maintain himself in this position voluntarily, it is recommended that the reverse lithotomy posture be used. This is done by depressing the head of the table and supporting the abdomen by sand bags placed in the groin, flexing the thighs and allowing the feet to hang over. It has been found in practice that when there are kinks, adhesions or angulations of the bowel it may be difficult to insert the instrument far enough at operation to find the growth if it is above the rectosigmoid junction. In such cases it strikes what appears at first glance to be a solid wall and cannot be made to go beyond it. To overcome this, the writer advises that a ball of cotton on the end of a placental forceps be pushed into the center of the proctoscopic field which will at once show the direction of the gut; it may then be lifted up, straightened and the sigmoidoscope passed upward easily. When the growth is in full view, it is grasped with the forceps and snipped off at its base with a modified Eaves' wire snare. To be assured that it will be cut off at the proper place it should be held by the forceps and steadied, when not only the pedicle but the portion of the bowel from which it springs may be removed and the wall cauterized. The regulation Eaves' snare is 4 in. long but may be easily lengthened and the position of the rings adjusted to suit. If one does not cut deeply the resultant bleeding is negligible, but there may be a hemorrhage which cannot be controlled if a blood vessel has been severed. A good way to meet this is by applying to the bleeding

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spot a long handled artery clamp which can be left in place as long as desired; but as this cannot be withdrawn through the operating sigmoidoscope on account of the rings, the writer devised a special clamp for this purpose. This is an artery clamp with 12 in. handles in which the rings have been entirely eliminated and replaced by oval concave plates to permit a good hold. It is found that in using a hemostat with long handles it cannot be opened well enough to grasp a larger object; hence in this instrument the lock has been shifted further toward the center of gravity to permit the jaws to be separated widely. Such a clamp may be applied to a bleeding point high up in the bowel and left in place after the removal of the sigmoidoscope. Of course the possibility of a severe hemorrhage, whether the cold snare or a

high frequency cutting current is used, can never be excluded; hence the need of clamping the bleeding vessel. Such an instrument may find a further field of usefulness in the bleeding which may occur when a piece of tissue is excised for diagnostic purposes.

#### SUMMARY

1. Certain growths of the sigmoid are removable by the rectal route.
2. Spinal anesthesia is desirable.
3. Tumors of the posterior wall become more accessible in the knee—chest position.
4. When a growth cannot be reached because of a kink or angulation lift up and straighten the gut with a cotton pad on long forceps.
5. Control postoperative bleeding by special clamp.



# "CHIMS" (COPPER NEEDLES)

AS A THERAPEUTIC MEASURE

(A METHOD OF THE "OLD" SCHOOL OF MEDICINE IN KOREA)\*

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OF the therapeutic methods practiced for centuries by Koreans one still survives which is of uncommon interest. This is the introduction bodily of copper needles (called "chims" in Korea) into the abdominal cavity. Though the practice still survives, it seems to be dying out, or at least is used only rarely today. I have seen only 6 cases during twenty years of practice in Korea. Four of these were discovered incidentally; only two patients volunteered the information and connected present symptoms with the presence of the needles.

The use of "chims," or needling, as ordinarily practiced is a common method of the "old school." Ordinarily the needle is introduced into the tissues and withdrawn. The indication for such needling is swelling or pain, or both. The most common location is the joints, but very few regions are exempt.

The introduction of copper needles through the abdominal wall to be left in the abdominal cavity is rather a startling procedure and must call for heroism on the part of the patient. The needles are quite blunt at both ends and measure about 2 cm. to 10 cm. in length. In caliber they are about the thickness of the lead refills commonly used in lead pencils nowadays. They are not heated, and no antiseptic measure is used on needles, patient or doctor's hands, except that the "doctor" may wipe off the needle on his hair before proceeding with the operation! There is no special instrument available for the operation; these blunt needles are driven through by main force with a rotating motion. Two or three are introduced at one sitting, and the procedure is repeated after a week or more as indicated. In 1 case as many as

60 needles had been introduced into the abdominal cavity in this way over a period of several years.



FIG. 1.

In the case illustrated by the accompanying roentgenogram the patient came for symptoms of indigestion. He had very little pain and was quite sure that his present symptoms were not due to the needles in his abdomen. He said that he had "a little distress for two or three days after the introduction of the needles, after which he felt better." The needling had been begun eight years previously and 2 or 3 introduced at a sitting, a total of 34 over a period of four years. They were not mentioned by him in the clinic, being discovered by us during a fluoroscopic

\*Submitted for publication Feb. 15, 1931.

examination of the gastrointestinal tract. The roentgenogram shows 34 needles in a variety of sizes. The most amazing finding, readily seen in stereoscope, is the presence of 8 or 10 needles in the bodies of the lumbar vertebrae, partially covered in by a massive hypertrophic spondylitis. The presence of these foreign bodies has produced a marked thickening and fusion of the bodies of the vertebrae.

This patient was not operated on, but 3 others have had laparotomy performed.

The striking feature in all these was the scarcity of gross pathology. There were no adhesions or kinks, the intestines were free and the needles were imbedded in scar tissue in the omentum and mesentery. Locally even there was so little thickening that the needles were hard to locate.

The outstanding facts in these cases are the absence of acute peritonitis in spite of the lack of antiseptic measures, and the absence of embarrassment to the abdominal organs in spite of the presence of these foreign bodies.

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# VASCULAR DISEASES OF THE EXTREMITIES

## IV. THROMBOANGIITIS OBLITERANS\*

### A REVIEW

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**T**HROMBOANGIITIS obliterans was first described in 1856 by Charcot, but its actual recognition, clinically, dates from the report of a case by Winwater in 1879. Being unfamiliar with the histopathology in the various stages of the disease, he incorrectly named it endarteritis obliterans. This term is still used by modern authors as are also the non-descriptive, presenile gangrene, Buerger's disease, and many others. It was in 1908 that Leo Buerger, after an exhaustive study, established the disease as a definite clinical and pathological entity and properly termed it thromboangiitis obliterans, which is a no less complete definition than is that one usually given in a few brief introductory sentences.

### ETIOLOGY

The cause of this occlusive thrombotic process is as yet unknown, but a microbial agent seems to be the most probable one, because in the involved vessels, early in the process of healing, there occurs an inflammatory lesion which shows a specific and characteristic morphological picture, and in the acute stage certain purulent foci are usually in evidence.

Syphilis was once thought of as a cause, but as positive Wassermann reactions are present in less than 10 per cent of the reported cases, one may assume that its existence is merely a coincidence.

### CONTRIBUTORY ETIOLOGIC FACTORS

Buerger contended that the disease rarely attacks other than the Semitic male, especially those of Russian origin. Of 500 patients observed by him, only 10 were Gentiles. Of this number, only 3

were females and in these the diagnoses were merely clinical ones. From a review of the more recent reports it is evident that the disease occurs more commonly in the Hebrews than in other peoples. Allen and Brown of the Mayo Clinic report that 50 per cent of their 200 cases were Jews, the remaining 50 per cent being Austrians, Finns, Norwegians, Germans, Scots, Irish, French, English, Dutch, Greeks, native Americans, and those of mixed ancestry. It has been reported in Swedes by A. J. Ochsner, in Koreans by Ludlow, in Turks by Wieting, in Norwegians by Timme, and a questionable case has been recorded by Gemmill in a negro. Whyte has observed the disease in the Chinese, and Meleney and Miller reported 24 cases in this race, one of which was a woman. By means of a questionnaire, they determined that out of 119 physicians, 51 had observed thromboangiitis obliterans in the Chinese. Ito reported it as occurring among the Japanese, and Koyana collected 120 cases occurring in this race. Tilford and Stopford reported 2 typical cases occurring in English females. Jablons observed 1 case in a female and confirmed his diagnosis microscopically. Idelsohn reported that out of 136 cases, which occurred in the Baltic provinces, only 60 per cent were Jews. Thus, it is evident that the disease is almost completely sex limited, but that its geographical and racial distribution is quite widespread. There is no proof that heredity plays an important etiological rôle. Because of the widespread occurrence of the disease, diet and obesity can be eliminated as possible causes. Occupation seems to be of no importance, although it is thought that exposure to cold hastens

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the appearance of the disease in those predisposed.

Allen and Brown suggest that the prostate may serve as a focus of infection, but state that the theory lacks proof as does the impression that any distant foci of infection are of etiologic significance.

Tobacco smoking has been shown to be more prevalent in patients with thromboangiitis obliterans, but one must not lose sight of the possibility that smoking might have been initiated in some cases in order to make this painful and chronic disease less unbearable. Allen and Brown found that 20 per cent of all the adult male patients at the Mayo Clinic denied the use of tobacco, whereas only 1½ per cent of those with thromboangiitis obliterans were total abstainers. One per cent of Buerger's 500 cases, 4 per cent of Jablon's 200 cases, and 10 per cent of Perla's 41 cases denied the use of tobacco; but of Meleney and Miller's series of 24 cases, 40 per cent were total abstainers. That smoking is a contributory etiologic factor seems likely, but absolute proof of this is lacking.

The age of onset of thromboangiitis, as given by Perla, is from twenty to forty-five years; Allen and Brown give the age of onset from seventeen to sixty-four years, with the highest incidence from thirty to fifty. Franenthal reported a doubtful case in a child of three. Koyano observed a patient whose symptoms began at nine years and there are several other cases recorded as occurring in the first decade of life. Buerger found the age of onset in his large series to range from seventeen to fifty-six years, with an average age of thirty-two. However, he states that these figures are much too high since it is very difficult to estimate the exact age at which the disease began, because of the insidious nature of the onset and because of the fact that it is overlooked in many cases. It must be borne in mind that remissions are common and have been known to last twenty years, that histories are inaccurate, and that a progressively increasing col-

lateral circulation may delay the appearance of symptoms.

#### CLINICAL COURSE

Thromboangiitis obliterans occurs most frequently in one or more of the extremities and first manifests itself when the circulation becomes inadequate for increased or prolonged activity of the part. There are in most instances indefinite pains in the sole of one foot, in the ankle, or in the toes, or there may be sudden cramp-like pains in the calf or elsewhere in the affected extremity. Other patients may have a feeling of numbness or coldness in the feet, especially in cold or damp weather. Rest or heat may relieve these, but after weeks or years evidences of trophic disturbances are present. Following trauma or without apparent cause, an abraded spot or hemorrhagic bleb, a pustule, or a dry, dead patch of skin develops near the tip of the toe or under a nail. Now the pain becomes excruciating even in inactivity, as during the night.

It is during the stage of trophic disorders, or probably only when intermittent claudication is present that the characteristic blush of the toes and foot is observed when the part is in the dependent position. At first this blush, or bright red hue is noted in the affected toe, but it spreads rapidly to the others and may even extend above the ankle. This symptom is referred to infrequently as erythromelia. On elevation of the affected part, a true ischemia rapidly develops. Conservative treatment may result in a remission or the symptoms may persist. The dorsalis pedis and post-tibial arteries now usually fail to pulsate, and the erythromelia and ischemia may be elicited at will. Ultimately, with or without treatment, gangrene develops, the pain becomes unbearable, and not infrequently a superficial thrombophlebitis makes its appearance.

#### CLINICAL TYPES

Some of the more common clinical types are as follows:

1. Those with pain or intermittent claudication and rubor, but without trophic lesions.

2. Those who have had vague symptoms, but on examination are found to have definite evidence of the disease.

3. Those who have ignored symptoms, but seek advice for trophic disturbances.

4. Those who seek advice for symptoms in one extremity, but are found to have had it for sometime in another.

5. Those in whom the disease is running an orderly and rapid course.

6. Those who are apparently cured or are in a stage of remission.

7. Those running a slow but progressive course.

8. Those in whom both upper and lower extremities are involved.

9. Those presenting with gangrene and running a fulminating course.

#### SITES OF LESIONS

Of Buerger's 100 cases, there were 171 lower extremities involved, and when one alone was affected, the left was involved three times more frequently than the right. Of the upper extremities, in 21 cases, the arms were involved thirty times, the left being affected in 7, and the right alone in 5. Twenty-one cases showed involvement of upper and lower extremities. All four were affected in 8 cases; 2 lower and 1 upper in 10 cases; 2 upper and 1 lower in 1 case; 1 upper and 1 lower in 2 cases. Koyano, in a series of 125 cases, found associated involvement of upper and lower extremities in 30 per cent.

Allen and Brown found little difference in the frequency of involvement in the right and left extremities. The frequency of involvement of the arteries they state as follows: the dorsalis pedis, post-tibial, popliteal, and femoral in the lower extremities, and the ulnar and radial in the upper extremities.

Buerger has observed what he terms the acute lesions in territories other than the vessels of the extremities; namely, in the spermatic artery, in the veins of the sper-

matic cord, and old lesions were found in one of the branches of the gastric artery in a case of ulcer of the stomach. Spiegel reported an authentic case with involvement of the mesenteric vessels. Meyer reported a case in which an operation was performed for symptoms of intestinal obstruction in a man suffering with thromboangiitis obliterans. At operation the mesenteric vessels, as well as the iliacs, were found markedly thickened and sclerotic. Unfortunately, a microscopic examination was not made. McGregor and Sims reported a case in which the spermatic vessels were involved. Linenthal and Barron believe that the disease may occur anywhere in the vascular system and suggest that symptoms of angina pectoris in early life may be due to thromboangiitis obliterans. That arteriosclerosis may develop centrally in those affected with thromboangiitis obliterans, is well known, and it is likely that the development of this process may obscure a once present typical lesion of thromboangiitis obliterans.

Lemann deplors the fact that up through 1928 there had been only 6 autopsies performed on patients who were definitely known to have had thromboangiitis obliterans. Buerger reported 4 of them and found coronary arteriosclerosis in one, thromboangiitis obliterans of the coronary vessels in another, and central arteriosclerosis with bland thrombosis in two. Perla reports that he found the typical lesion of thromboangiitis obliterans in the coronary vessels of one of his cases. Lemann's autopsy was the sixth, and this was on an elderly patient who had suffered for many years with thromboangiitis obliterans of the extremities. The coronary vessels showed advanced arteriosclerosis with occlusion.

#### SYMPTOMATOLOGY

Allen and Brown state that pain of claudication was the first symptom in 51 per cent of their cases, the longest history being fifteen years and the shortest two months. Coldness of the extremities was

the first symptom in 12 per cent; abnormal fatigue in 11 per cent; non-healing ulcer in 10 per cent; sudden arterial occlusion in 7 per cent; recurrent superficial phlebitis in 4 per cent; edema in 3 per cent, and vasomotor disturbances of the spastic type in 2 per cent.

The disease manifests itself in the early stages in different ways. Most patients give a history of fleeting, indefinite pains in the foot or toes. Others may be conscious only of the toes or foot becoming cold and numb in cold or inclement weather. Frequently, cramp-like pains may occur in the calf muscles when walking. This is the characteristic pain of intermittent claudication, which at first is relieved by rest, but later becomes more constant as collateral circulation begins to fail. Some few patients may give a history of pain and tenderness, with redness at times over the superficial veins of the extremity, which is due to the migrating thrombophlebitis stressed by Buerger, who claims that it occurs in 25 per cent of cases. Its occurrence, if not pathognomonic in itself, affords an opportunity for study of the characteristic lesions.

These symptoms are characteristic of the early stages of the disease and may persist for weeks, months, or even years, followed by a series of trophic changes or gangrene. The most common sites for ulcerations are on the outer or inner margin of the big toe adjacent to the nail, the outer aspect of the little toe, the middle of the second toe, the middle of the dorsum of the foot, the inner aspect of the ankle inferior to the internal malleolus, and on the anterior aspect of the leg over the tibia. The slightest trauma may be sufficient to produce these changes. Frequently they arise spontaneously from infarcts being preceded or accompanied by increased and persistent pain which is not relieved by rest. Pain may be considered as an index of the degree of vascular obliteration.

At any stage of the disease a new and characteristic sign may make its appear-

ance. This is the erythromelia or peculiar blush which begins in the affected toe or toes and then gradually extends up the dorsum of the foot and sometimes to a short distance above the malleoli. It is best observed with the foot in the dependent position. The characteristic ischemia when the extremity is raised above the horizontal position also may be elicited.

Palpation will reveal at this stage a loss of pulsation in the dorsalis pedis, posterior tibial, possibly popliteal, or even the femoral arteries. The surface temperature of the part is markedly lowered especially when ischemia is produced. Both lower extremities are likely to show these changes, but if only one is involved the contrast between the two is marked.

If ulcerations are present, these are frequently infected, as evidenced by the accompanying lymphangitis or cellulitis with edema.

A later examination reveals localized or spreading gangrene, and frequently the patient pleads for an amputation in order to rid himself of excruciating pain which morphine has not relieved.

#### PATHOLOGY

The characteristic thrombotic lesions which are consistently seen in the deep and larger arteries and veins and occasionally in the superficial veins, may be divided into the acute and healed stages for purposes of study. At the time of amputation we only expect to encounter the healed lesions unless migratory thrombophlebitis is present.

The healed vessel grossly appears to be filled with a grayish or yellowish mass that can be differentiated from the intima and shows one or more fine openings through which a minute drop of blood can be squeezed. The vessel wall itself is usually contracted so that it appears thickened. If the lesion is old enough there may be some accompanying arteriosclerosis which partially obscures the original picture. Characteristically there is a marked periarteritis which binds together accompany-



ing nerves and other vessels which may present the disease in a different stage.

Microscopically the occluding mass is seen to be organized tissue rich in canalizing vessels about which there may be a sparse amount of elastic tissue. The intima which can readily be differentiated, is merely thickened by contraction and shows infiltration of new vessels which penetrate to the occluding tissue. Unless the lesion is a very old one or has occurred in old age, there is no splitting and reduplication of the interval elastic lamina which is characteristic of arteriosclerosis. This important differential point is strikingly demonstrated with an elastic tissue stain. The media appears atrophied and infiltrated with new vessels some of which penetrate toward the old thrombus. The adventitial coat shows a characteristic fibrous tissue proliferation which indicates that it has been the seat of inflammation and serves to differentiate the whole lesion from one of arteriosclerosis.

On tracing out the occluding tissue we find that it extends upward to end in a practically healthy vessel wall as a rounded or convex projection, or it may be capped by an additional more recent red or brown thrombus which rises in pyramidal fashion.

The acute lesion is striking and pathognomonic, but the opportunity for observing it rarely presents itself.

Grossly the vessel wall appears thickened and red and within it is a recent red or brown soft thrombus.

Histologically the earliest changes are those of an acute inflammatory process involving all coats of the vessel. The intima, the media, the adventitia and perivascular tissues are infiltrated with polymorphonuclear leucocytes and the lumen of the vessel is completely filled with red clots. In the peripheral portions of the thrombus, large or small foci of leucocytes (purulent foci) begin to form. The remaining portions of the clot show an infiltration of leucocytes; but this may be seen undergoing organization while the purulent foci develop into

the typical giant cell foci, containing giant cells, endothelioid or angioblasts, and broken down leucocytes. Ultimately, these foci undergo organization. The giant cells disappear and new vessels penetrate, the final product being a fibrous nodule containing vessels and some pigment.

In the media the muscle fibers are split by the leucocytic infiltration which ultimately disappears to be replaced by newly formed vessels some of which penetrate the clot.

The adventitia also shows a leucocytic infiltration which later gives way to a fibrous tissue proliferation.

In short, the lesions in thromboangiitis obliterans are, in chronological order, an acute inflammatory lesion with occlusive thrombosis, the formation of miliary giant cell foci, the stage of organization with the disappearance of the miliary giant cell foci, the organization and canalization of the clot, the disappearance of the inflammatory products, and the development of fibrotic tissue in the adventitia, that binds together the artery, vein and nerves.

When the lesion has existed for many years, a secondary thickening of the intima takes place with corresponding proliferation of elastic fibers that must not be confused with arteriosclerotic processes.

It is true that atherosclerotic plaques in which the elastic fibers are arranged more or less parallel with the internal elastica lamina, may encroach upon the lumen of the vessel because the two diseases may be associated. It must be admitted that a predisposition to vascular disease, as it manifests itself in certain cases, seems to express itself both in a susceptibility to thrombotic lesions as well as to degenerative ones. Autopsy findings in cases of thromboangiitis obliterans show that the more centrally situated arteries develop a tendency to arteriosclerotic lesions even though the arteries of the extremities show but little sclerosis.

That the accompanying nerve may be

included in the periarterial fibrosis has been mentioned. In addition, the nutrient blood vessels supplying the nerve may be affected. Meleney and Miller report that all of their cases with pain showed this nutrient vessel occluded. This may also account for some of the trophic changes which accompany the disease. Changes in the nutrient vessel supplying the bones have not been described although roentgenograms show an accompanying rarefaction and decalcification, particularly in cases where gangrene is impending or has already developed. However, in localized gangrene of the toe, the bone may be entirely unchanged in spite of the extensive necrosis of the tissues surrounding it.

There are no characteristic changes in the muscles, although in long-standing cases atrophy occurs due to impaired circulation.

The interference with the blood supply and the involvement of nerves give rise to changes in the skin and skin appendages. Thickening, hyperkeratosis, and scaling are frequently seen. Alopecia may occur, and the nails show changes varying from mild ridging to marked hyperplasia with deformation and incurvation. Ulcers commonly develop under the nail bed, over the tibia, on the plantar surface of toes, or immediately below the malleoli.

When the occlusive thrombotic process becomes too extensive for the collateral circulation to compensate, gangrene of the infarct type develops and spreads with the extension of the thrombosis and the inevitable infection.

Willy Meyer reported a series of 34 cases in which the average red blood cell count was over 5,000,000, and the hemoglobin about 95 per cent. Jablons states that there were only occasional variations from the normal values in his series. Thomas and Christianson have reported cases in which a leucocytosis persisted, but studies of the white blood cells by Jablons showed that 72 per cent of 36 cases had a leucocyte count of between 5000 and 10,000. Allen and Brown found

white and red blood counts normal in their large series.

#### DIFFERENTIAL DIAGNOSIS

The first distinction to be made is that between an organic or occlusive vascular disease and a functional or vasomotor disease. This can be done in most cases by repeatedly determining the state of pulsation in the peripheral vessels. It is in eliciting this that the Pachon oscillometer will often prove a valuable aid and rarely obviate an error in diagnosis in case of an anomalously coursing vessel. Raynaud's disease is characterized by a sudden onset with local syncope or regional ischemia involving the fingers more rarely the toes, and occasionally the ears and nose, short duration of the sensory and vascular manifestations and their intermittent character, symmetrical gangrene, and absence of arterial occlusion. This disease characteristically attacks the young female, whereas thromboangiitis obliterans is of doubtful occurrence except in the male.

Acrocyanosis, a progressive, slowly developing asphyxia of the ends of the extremities, with local hyperesthesia is generally associated with pulmonary osteoarthropathy.

In erythromelalgia, there is a chronic localized hyperemia with pain and swelling when the feet are dependent. The attacks are relieved by elevation of the part and the application of cold. Ischemia does not occur.

Sclerodactylia and scleroderma are generally symmetrical and though they may present vasomotor signs of asphyxia and syncope, they are characterized by shortening of the fingers due either to a contraction of the skin or absorption of the terminal phalanges, which can be recognized roentgenologically. The differentiation of thromboangiitis obliterans from arteriosclerosis with occlusion is not always readily made.

In arteriosclerotic endarteritis obliterans, with or without diabetes mellitus, the age of the patient is usually over fifty; vasomotor phenomena are infrequent; gan-

grene, which may be of the moist type, supervenes earlier after the first symptoms and progresses more rapidly; the physical manifestations of impaired circulation are few prior to the onset of gangrene; pain is less marked; migrating phlebitis does not occur, but marked varicosities of the superficial veins are more frequent. It is seldom found in the upper extremities. Its presence is readily demonstrated by roentgenograms.

The early diagnosis of thromboangiitis obliterans is most essential from a therapeutic standpoint. This is usually simple, but at times may be made only on age of the patient, sex, excessive pain, or the occurrence of a migrating thrombophlebitis.

#### PROGNOSIS

Perla gives the average life of limb in his series as one to two years after onset, but he had one case in which the duration of the disease was twenty years. Two of his patients had remissions of fifteen years, and 9 of them were symptom-free from three to five years.

Buerger had one patient in whom gangrene did not occur until twelve years after onset of the disease; also many in whom there were remissions of variable periods; but, nevertheless, he gives a rather gloomy prognosis as to life of the affected extremity. Other authors have given an equally unfavorable prognosis; but from reports in the more recent literature, one is led to conclude that either the disease is more chronic and more slowly progressive than was formerly thought, or that conservative therapy is of distinct value.

Allen and Brown conclude that "thromboangiitis obliterans is apparently a self-limiting disease, as the obliterative process eventually stops." On consideration of the clinical course, it becomes evident that there is a simultaneous arterial obliteration and reestablishment of circulation both in the old thrombi and in the newly developing collateral channels. Trophic changes,

as gangrene and ulcers, occur as obliteration progresses. Amputation seems inevitable and is necessary at times; but frequently, as the compensatory circulation increases and becomes established to a high degree, the trophic changes disappear, and the patient may be symptom-free for years or perhaps indefinitely.

Trophic changes accompanied by severe pain, even when at rest, or infection with edema usually progress to extensive gangrene requiring amputation.

The economic factor greatly influences the prognosis. Patients who cannot afford long periods of rest with institution of conservative measures, usually require high amputation performed early. However, patients in whom the condition is diagnosed early and who cooperate with a physician in an attempt to establish collateral circulation may expect either a low amputation or perhaps a useful extremity for years or even for life.

#### TREATMENT

Multiplicity of therapeutic measures advocated for a given disease indicates that no one is entirely satisfactory, and usually that none of them strikes directly at the predominating etiological factor. This is the case in thromboangiitis obliterans, but at least progress is being made toward conservatism.

The stage of the disease should determine the treatment. Four stages may be recognized:

1. Extensive gangrene with or without pain. The treatment is high amputation.

2. Severe "rest pain" with or without moderate trophic changes. The treatment consists of measures for relief of pain, methods to increase circulation, removal of foci of infection, and, in a limited number of cases, lumbar ganglionectomy and rami section may relieve pain and increase circulation. If these measures fail, amputation is indicated.

3. Mild trophic changes without "rest pain." The treatment should be designed to increase circulation. Foci of infection

should be removed and prolonged rest enforced. Lumbar ganglionectomy and rami section are of value in certain cases.

4. Neither "rest pain" nor trophic changes. The treatment consists of rest, removal of foci of infection and conservative measures to increase circulation.

Cessation of smoking is indicated in all cases as its vasoconstricting action prevents a maximum development of collateral circulation. The removal of foci of infection is advisable in all cases to improve the general condition of the patient.

Avoidance of excessive exercise, wearing of tight shoes, exposure, and trauma are indicated to lessen the occurrence of trophic changes.

Means for increasing circulation are numerous and may be grouped as follows:

1. Physical means. Heat in various forms is of benefit. It may be administered by baking, diathermy, heat tents, and other means, but is probably most efficacious when administered as hot sitz baths. Contrast baths produce a vaso-dilating effect; but cold if continued too long is dangerous in these cases, and is, therefore, contraindicated.

2. Mechanical measures include Buerger's postural exercises, which are of definite benefit in the young, but are too exhausting for elderly people. With the patient lying in bed, the affected extremity is elevated to from 60 to 90° above the horizontal, allowing the part to rest upon a support for from thirty seconds to three minutes in order to produce ischemia. As soon as blanching occurs the patient then hangs the leg down over the edge of the bed long enough for the characteristic rubor to set in. The limb is then placed in the horizontal position for three to five minutes, during which time heat should be applied. This procedure should be repeated for one hour, as many times a day as seems practicable. Hyperemia, induced according to the method of Bier, is another method included in this group.

3. Measures affecting the vasomotor system include the use of vasodilating

drugs, such as nitroglycerin and the nitrites, which are of doubtful value. The administration of typhoid vaccine to induce fever and a vasodilating action in the collateral channels of the diseased extremity have been shown by Brown and Allen to be of distinct value. These observers have demonstrated by calorimetric methods that during the fever there is a distinct increase in blood flow through the affected extremity. Goodman and Gottesman suggested the use of typhoid vaccine intravenously for induction of fever. The initial injection should contain 40,000,000 killed organisms and should be repeated five times at daily intervals in doses which are increased sufficiently to produce a chill and a 2 to 4° elevation of temperature. Although exhaustive in repeated courses, its beneficial effect on pain and trophic changes warrant its use within conservative limits in practically all cases.

4. Measures designed to affect the blood directly, include the administration of various solutions as infusions and clyses.

Koga in 1913, hoping to decrease the blood viscosity, advocated hypodermoclyses of Ringer's solution. This method immediately became popular and various modifications of it are still being used with presumably favorable results.

Steel advocated the use of sodium citrate in Ringer's solution intravenously, reasoning that clotting would be decreased. Buerger states that the results obtained by this therapy hardly warranted its use. However, Jablons reports favorable results from the employment of an elaborately prepared citrate solution. Twenty grains of sodium citrate are dissolved in 100 c.c. of freshly prepared doubly distilled water to which 3 gm. of sodium chloride are added. The addition of 1 gm. of dibasic potassium phosphate is usually required to render the solution iso-electric as well as isotonic. This latter acts as an anti-coagulant, and when present in certain concentrations, prevents the occurrence of the severe chills which follow the use of sodium citrate in distilled water. The

solution is filtered and sterilized in an autoclave. Two hundred fifty cubic centimeters of the solution are administered intravenously every day for ten days, and then given at two-day intervals for a period of six months. After this, improvement usually warrants an interval of a week for the next year. Of Jablons' 120 patients treated in this way for one to three years, 60 have been symptom-free.

Willy Meyer claimed beneficial results after flushing the intestinal tract daily with 8 to 10 qt. of Ringer's solution through a duodenal tube and supplementing this with daily hypodermoclyses of the same solution. Allen and Brown have used radium chloride intravenously and have found that it relieved pain in 70 per cent of cases. However, they found it to be an expensive procedure and no more efficacious than the administration of typhoid vaccine.

At Mount Sinai Hospital, in New York, Silbert and Samuels have reduced the percentage of amputations from 77 per cent to 10 per cent by the intravenous administration of hypertonic salt solution. Three hundred cubic centimeters of 5 per cent sodium chloride solution are given three times a week over a long period of time. Of 84 cases so treated by Silbert, only 12 per cent have required amputations in four years.

5. Surgical procedures on the vessels in a large series of cases have been reviewed by Etto and Stelton, who reported failures in over 70 per cent of cases. These procedures are ligation of the femoral vein, as advocated by Oppel, Morton and Lilienthal, and arteriovenous anastomosis, as practiced by Weiting, Goodman, Satrustegen and Davies.

Ligation of the femoral artery as practiced by Lewis and Reichert in arteriosclerosis, hardly seems a rational procedure to institute in a disease which itself occludes the arteries.

Since Pearse has shown experimentally that simultaneous ligation of the artery and vein results in improved circulation

peripherally, it seems that vein ligation in this disease should produce like results. Pearse and Morton have utilized this procedure for some time and report gratifying results from it. Van Gorder, in Peking, reports that of 9 patients so treated eight were improved or actually relieved of their gangrene.

6. Measures to lessen pain are numerous. Although any procedure which increases circulation lessens pain, it has seemed important to obtain immediate relief. Analgesic drugs give only partial relief, and morphia for obvious reasons is undesirable.

White and Smithwick inject alcohol into the anterior and posterior tibial nerves and the lateral cutaneous branch of the peroneal nerve. Also 6 inches above the ankle between the tibia and fibula the medial cutaneous branch of the peroneal nerve may be exposed and injected. If the anterior and posterior tibials are injected in their lower thirds only, the intrinsic muscles of the foot are affected and gait is only slightly disturbed. This procedure affords relief for six weeks and allows improvement in that necrotic areas may be attended to without inducing pain. This measure does seem of value but no doubt ulceration may occur at the site of injection.

7. Local treatment. Trophic ulcers are treated on general surgical principles. For local pain Buerger suggests the use of an analgesic ointment containing 5 per cent novocaine and 10 per cent orthoform or anesthesin in lanolin and glycerine. Migrating phlebitis is best treated by application of hot wet dressings.

8. Surgery of the sympathetics. Adson and Brown have shown that lumbar ganglionectomy and ramisectomy produce definite and persistent vasodilatation of the vessels of the feet when vascular dilatation is obtainable.

In thromboangiitis obliterans, in addition to occlusion, there is also a vasomotor factor which is probably due to impulses arising in inflamed vessel walls and being

carried to the spinal cord reflexly produce a vasoconstriction or prevent maximum vasodilatation. If the lumbar sympathetic chain is removed, this reflex arc is broken and there results a diminution in vascular tone and a vasodilatation permitting an increased blood flow in certain cases. Brown has determined that this procedure is applicable to only 1 out of 7 patients with thromboangiitis obliterans. He calculates their vasomotor response by giving typhoid vaccine and determines the rise of surface temperature and oral temperature. If the increase in oral temperature is subtracted from the increase in surface temperature and the result divided by increase in oral temperature, a so-called "vasomotor index" is obtained. If this index is 1.5 or more, a favorable result may be expected from lumbar ganglionectomy and ramisection.

Periarterial sympathectomy, as originally advocated by Leriche, has given uncertain results and is seldom practiced. Bernheim terms it "a tiding over process," which should be used in selected cases as it frequently relieves pain and is easy to execute.

9. Roentgen-ray therapy. Philips reports relief of pain and improvement of circulation in cases of thromboangiitis obliterans subjected to radiation of the lumbar segments of the spine. Beall and Jagoda report an apparent cure following such therapy.

10. Surgery of the extremities. Formerly high amputations of the extremities were performed early in the disease without due regard for the state of the circulation. However, with the advent of conservatism, one finds that indication for amputations are not clearly defined. Cases are being reported in which medical treatment has reestablished function in an involved extremity. Gangrenous lesions have been seen to heal, and Mills reports that func-

tion remains in the feet of stoic Chinamen whose toes have undergone autoamputation. To generalize, one might say that cases in which gangrene is limited to the toes should be treated medically, provided that pain can be relieved and economic conditions permit it. Those treated surgically should have the benefit of post-operative medical treatment to facilitate healing.

Incision of toes and removal of toe nails usually result in spreading gangrene and therefore should never be practiced. The level at which amputation should be performed can be determined only after an investigation of the status of the circulation. If in an attempt low amputation, vessels are found diseased, a higher level should immediately be tried rather than re-amputation at a later date. However, Allen and Brown state that amputation below the knee is successful in 80 per cent of all cases of thromboangiitis obliterans, regardless of the condition of the pulsations in the popliteal artery, provided that the gangrene does not involve the leg and extensive lymphangitis or edema is not present. They also add that combined intensive medical treatment has made possible such results.

Fingers can usually be amputated successfully regardless of obliteration of ulnar or radial arteries. Toes may be successfully amputated in that small group of cases in which either one or both of the main vessels of the foot are pulsating normally. Amputation of the distal half of the foot or above the ankle offers no functional advantage. Amputation below the knee joint offers a distinct functional advantage and is successful when popliteal vessels are patent. If the latter are occluded, amputation should be done above the knee unless medical treatment can be properly instituted.

[For References see p. 488.]



# VISUALIZATION OF THE BILE DUCTS

## FOLLOWING THE ADMINISTRATION OF A BARIUM MEAL\*

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A REVIEW of the literature to date reveals that no more than 10 cases have been reported showing barium in the biliary ducts as seen roentgenographically, following the administration of a barium meal. In addition to these reports 3 other cases have been incidentally mentioned in papers dealing with other phases of the roentgenological examination of the gastrointestinal tract by the contrast method. Recently we have observed 2 such cases, the first in our fifteen years of experience, and this, together with the scarcity of the literature on the subject, leads us to believe that the phenomenon is by no means a common one.

Kantor and Jaffin<sup>1</sup> give a comprehensive review of the 7 cases reported up to January 1928, and add 2 more of their own. Their first case showed a thin stream of barium radiating upward from a markedly deformed duodenal bulb, apparently through a fistula formed by rupture of a penetrating ulcer into the bile duct. The patient had had an operation ten years previously, at which time adhesions involving the hepatic flexure, duodenum, and cecocolon, were separated, and the appendix was removed. Seven months later a cecopexy was performed on a large pendant cecum, and adhesions which were found in this region were separated.

Their second case showed a free filling of the biliary ducts well into the liver substance, and, based on the history was thought to be due to a spontaneous choledochoduodenostomy, probably of eighteen years' standing. In neither case was the gall bladder outlined.

Swalm and Manges<sup>2</sup> give a very complete report of a case which they have observed, where the gall bladder had been removed, and a choledochoduodenostomy

performed. During a gastrointestinal examination barium passed into the biliary ducts and down into what appeared to be the common duct, where it was arrested at the occluded lower end, and where it remained as a residue for twenty-four hours.

Harding<sup>3</sup> in reporting "A roentgen study of the lesions of the stomach and duodenum, etc.," mentions a case of duodenal ulcer which had perforated into the gall bladder, and through the resulting fistula barium passed readily into the biliary ducts during a gastric roentgenological examination. The presence of the fistula was verified at operation.

Johannesson<sup>4</sup> mentions 2 cases where there was regurgitation of barium into the common duct. One case at operation revealed a chronic cholecystitis, and a stone the size of a pigeon's egg located in the common duct. The other showed a chronic cholecystitis, with a large thick common duct, with no evidence of stone. Apparently in neither case was a fistula present.

We wish to submit our reports of 2 additional cases.

CASE 1. A man, aged fifty-nine, was admitted to the hospital April 15, 1930, complaining of discomfort across the upper abdomen, and of precordial pain which radiated down the arms, particularly the left. Eighteen years ago an incision was made over the gall bladder and the abdomen opened, but on account of the presence of adhesions, or the discovery of other pathology, the wound was closed without further surgical interference, and on the following day a gastroenterostomy was performed. The reason for either operation could not be determined from the history.

For the last few years the patient had had considerable pain and discomfort in the upper abdomen, which had become more severe during the last three months. The pain had

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been fairly constant, and was not particularly affected by the ingestion of food. He also had severe attacks of dyspnea accompanied by

mediastinum was clear; the excursions of the diaphragm were normal. The esophagus showed no pathology. The stomach was normal in size,



FIG. 1. Barium in biliary ducts following barium meal.

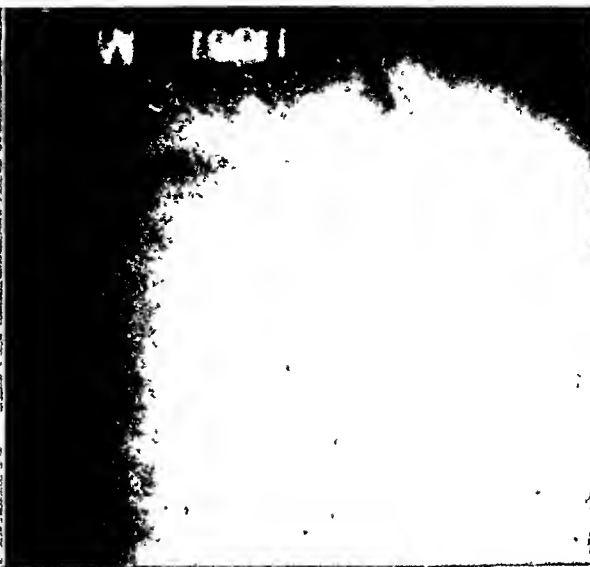


FIG. 2. Dilated ampulla of Vater. Barium filling common duct and extending upward beyond bifurcation.

precordial pain radiating to the shoulders and down the arms, and lasting about one-half hour, which occurred at infrequent intervals, and did not appear to be related to the abdominal distress.

*Physical Examination:* The abdomen was tender in the region of the scar over the gall bladder, and below the scar an indistinct mass could be palpated suggesting an abundance of scar tissue. At the upper portion of the second scar to the left of the midline was a small ventral hernia.

The heart was regular in rate and rhythm, and did not appear to be enlarged. The heart sounds, however, were rather indistinct. No adventitious sounds could be elicited. The pulse was of good quality. Occasional moist râles were heard over the chest posteriorly. There was a fistulous tract in the region of the anus which was draining slightly. The temperature, pulse, and respirations were normal on admission. The blood count showed 4,410,000 red cells, 14,100 white cells, and the hemoglobin was 82 per cent. The urine was negative except for a few pus cells.

On April 17 we made a roentgenological examination of the gastrointestinal tract. Both the heart and the aorta were increased in their transverse diameters, the posterior

shape, and position. There was a gastroenterostomy on the greater curvature of the pars media, which was functioning normally and was freely movable, and which was not tender on palpation. The liver shadow was somewhat enlarged. The duodenal bulb was fixed to the under surface of the liver, and the apex of the bulb was irregular. Practically no barium could be identified passing from the duodenal bulb through the afferent loop of the enterostomy. Fluoroscopically, a narrow tract of barium leading from the deformed bulb up towards the liver, could be seen, and in the films barium could be identified high in the right upper quadrant outlining some of the biliary ducts (Fig. 1). The colon was negative.

On April 21 after the administration of tetraiodophenolphthalein by the oral method, it was found that none of the dye had entered the gall bladder. In the gall bladder films some of the biliary ducts were still outlined by the barium remaining therein, four days after the administration of the barium meal.

During these days in the hospital the patient was comparatively comfortable, complaining only of some weakness and slight pain in the upper abdomen. The leucocyte count varied between 11,000 and 14,000, and the urine at times showed a small amount of albumin and



bacteria. The temperature, pulse, and respirations remained normal, and there were no anginal attacks since admission.

On April 24 the abdomen was opened through a gall-bladder incision. The stomach was found to be pulled over to the right and fastened by adhesions to the former gall-bladder incision. The omentum was firmly attached to the peritoneum in this area. The gall bladder was exposed by dissecting through the adhesions which were firmly fixed to the liver and duodenum. A fistulous tract about 1 cm. long was found extending from the second part of the duodenum to the middle of the gall bladder. This was severed and the stump on the duodenal side inverted. The gall bladder was dissected free and removed. No stones were found. The gall bladder measured  $2\frac{1}{2}$  in. in length, and  $\frac{3}{4}$  in. in diameter. The walls were very thick, and the bile contained therein was thick and dark.

Four days after the operation the patient began to have a recurrence of the anginal pains and there was evidence of a slow fibrillation of the heart. During the next few days these attacks became more frequent and severe and the auricular fibrillation more pronounced. Pericardial friction could be heard. Bile was flowing satisfactorily from the drain. On the eleventh day following the operation the patient died as a result of an acute coronary thrombosis. A post-mortem examination was not made.

**CASE 11.** Unfortunately a complete record of the history and physical examination of this patient are not available as she was not admitted to the hospital.

A woman aged fifty-three, had a cholecystostomy seventeen years ago, and subsequently underwent further operations, including appendectomy, oophorectomy, and removal of stones from the pancreas. Four years previous to the present examination she gave a history of an attack of jaundice, and her recent complaint was that of pain low down on the right side of the abdomen.

Roentgenological examination showed the heart and aorta to be within normal limits. The posterior mediastinum was clear. The esophagus showed no pathology. The stomach was hypertonic; no filling defects were evident on either curvature. The pyloric antrum was normal. The duodenal bulb showed no pathology. During the fluoroscopic examination

there appeared to be an extraluminal shadow in the region of the second part of the duodenum which had the appearance of a diver-

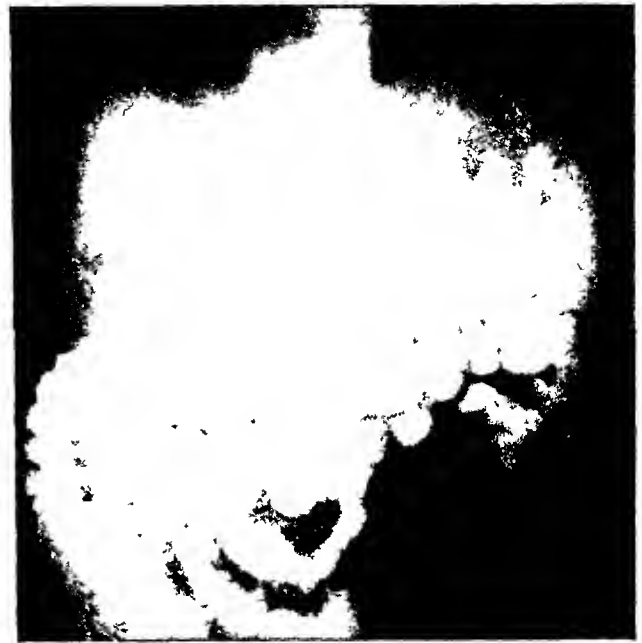


FIG. 3. Ampulla of Vater. Barium in biliary ducts filled after five hours.

tieum. The film (Fig. 2), however, showed this to be a dilated common duct which had filled with barium, and which extended to the left from the descending portion of the second part of the duodenum and then upward behind the proximal horizontal portion of the second part of the duodenum into the hepatic duct. The latter could be seen to bifurcate into ducts of equal size, and these, in turn, to split up and distribute themselves throughout the liver shadow. No shadow corresponding to the gall bladder could be identified. From the films it appeared that the barium entered the common duct through a dilated ampulla of Vater. The stomach was empty at the end of five hours, and in the five-hour film (Fig. 3) many of the smaller ducts scattered throughout the liver could be seen to contain barium. At the end of twenty-eight hours these ducts were practically emptied of their barium content, only a very few of the smaller ducts being outlined.

This patient has not been operated since the x-ray examination; therefore, the findings have not been confirmed. We believe, however, that the x-ray findings are quite conclusive in this case.

[For References see p. 547.]

# ACUTE GONOCOCCAL EPIDIDYMITIS

## A RÉSUMÉ\*

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**E**PIDIDYMITIS is perhaps one of the most frequent, most damaging and most important sociologically of the complications of gonococcal infection. It is the most frequent disease of the testicle. Epididymites from other bacterial etiology, tuberculosis excepted, are indistinguishable, clinically and pathologically, from those of gonococcal origin. Epididymitis has a rather high incidence, being variously estimated at from 10 per cent to 30 per cent. Wolbarst<sup>1</sup> believes that 5 per cent to 10 per cent is conservative, and his private records of 5000 cases of acute posterior infections show under 1 per cent. Taylor (quoted by Wolbarst) believes that 3 per cent is high. The records of the last 300 personally treated cases of gonococcal infection show an incidence of 33 cases or 9.9 per cent, 28 cases coming for treatment with the epididymitis developed and 5 cases or 0.6 per cent developed during treatment. Epididymitis is responsible for the vast majority of cases of sterility, due to occlusion of the vas.

### ETIOLOGY

The causes of epididymitis are variously stated, but a careful history will generally reveal that it starts within at least twenty-four hours after the following procedures: 1. The use of a strong irritating injection, forcefully given. 2. Injury to the posterior urethra by rough, unscientific instrumentation or catheterization. 3. Hydrostatic irrigation with too forceful a pressure. 4. Too vigorous prostatic massage or rough digital manipulation of the vesicles. 5. Prolonged and repeated sexual excitement with a distended bladder or excessive sexual intercourse in the presence of an urethral infection.

Sexual excitement is only a factor when

the bladder is distended. According to Pelouse<sup>2</sup> the main element is the increase of intraurethral and intravesical pressure, because the internal sphincter relaxes and the posterior urethra becomes virtually a part of the bladder cavity and the purulent gonococci-laden contents are subjected to great pressure, forcing them into the ejaculatory ducts. Improper massage is a very frequent cause as has been pointed out by us in previously published articles.<sup>3,4,5</sup>

Traumatic orchitis is indeed a misnomer, as applied to acute infections of the testicle, as has been pointed out by Wesson.<sup>6</sup> Epididymitis is common and orchitis is rare except as a complication of some systemic disease. A latent seminal vesiculitis and not trauma is responsible for the cases commonly and incorrectly diagnosed as traumatic orchitis. Extension would have occurred whether there had been a trauma or not. It has always been rather difficult for me to appreciate the rôle of a suspensory in preventing the spread of a urethritis to the epididymis, because we have seen patients develop this while wearing a suspensory and even while at rest in bed.

Gonococcal epididymitis may develop at any time during an acute infection, but usually develops at the height of the inflammation, but not infrequently occurs in chronic cases without apparent cause as noted in 8 of personally observed private cases. It is generally unilateral in 95 per cent of cases and more common on the left side. Double simultaneous epididymitis is quite rare; we have only seen 1 such case in nine years at The Lakeside Clinic. Subsidence in one organ with subsequent appearance in the organ on the other side is much more common. That the inflammation spreads to one side and not to the other

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may be due to the occlusion of one side by swollen mucous membrane, while the other remains patent. The clinical course is generally abrupt, gradually declining in five days under proper treatment. Death is rare, but sterility occurs in about 2 out of every 5 cases of bilateral epididymitis.

#### ANATOMY

Before we discuss the mechanism of epididymitis a brief review of the salient points of the anatomy will give us a clearer conception of the process. The epididymis caps the testicle, located on its upper and posterior surface. It is divided into the globus major, or head, the body, and globus minor or tail and is about 5 cm. in length. It is closely invested by the tunica vaginalis, except at the head and tail. Beginning at the head in the cornu vasculosis, a series of convoluted cones, bound together to form about twelve tubes, make up the globus major, which rests on the top of the testicle. They all join to form one single tube, which is very much coiled and twisted upon itself and is the body of the epididymis, which becomes further convoluted and forms the tail or globus minor. There is no compartment formation as at the head, but the coils are separate, but bound together at this point and united by connective tissue to the testicle. The canal is lined with ciliated epithelium and the peristaltic wave is toward the vas. The length is about 20 ft. and the diameter 4 mm.

From a clinical standpoint the tail is the most important. The junction between the body and the tail is quite irregular, the tubule here, separating out as a single tube and at this point making a number of acute angles upon itself and becoming large and thicker, meeting the vas deferens at an acute angle.

#### MECHANISM OF ACUTE EPIDIDYMITIS

It is only remotely possible for organisms to be carried along the lymphatics of the sheath of the vas to the epididymis; in fact, extension by this route is questionable,

despite the claims of Walther.<sup>7</sup> That the organisms are not carried along the mucosa of the passages by continuity, as infection spreads from anterior to posterior urethra, is demonstrated by the rapidity of onset of the epididymitis, far too fast for bacterial progression, and the absence of involvement of the mucosa except at certain isolated areas. There are also anatomical and physiological reasons. The ejaculatory ducts are only 2 cm. long but the vas is 45 cm. long and the gonococci must spread all this distance against a current of fluid and the peristalsis of the vas. It is also known clinically that at least 98 per cent of the cases of epididymitis develop before a vasitis and then generally at the epididymal extremity. It is also recognized that long, narrow, mucous channels rarely become infected through continuity with the surface.

We know that peristalsis of the vas does occur during coitus and is from the vas toward the posterior urethra; but no investigation has shown that it may be in the opposite direction. The theory of reverse peristalsis has many flaws that time will not permit discussion of, except to say that the ejaculatory ducts contain no circular muscular fibers that make peristalsis possible.

Then what is the mechanism by which the epididymis becomes infected? Rolnick<sup>8</sup> has produced clinical as well as experimental evidence that points to the lumen of the vas as the pathway of infection. There is mechanical transference of the purulent products, gonococci-laden, from one point to another, from posterior urethra to vesicles to vas deferens to the epididymi. The vesicles must be infected before the epididymis.

The posterior urethra becomes involved during an acute urethritis and the verumontanum is involved, and thus the gonococci-laden pus is drawn in and carried up the ejaculatory ducts. When not inflamed the sphincters of the ejaculatory ducts are in a state of contraction; but, when they are inflamed or mechanically

irritated or traumatized, they lose their tone and bacteria can travel up, with edema and occlusion following. The sem-



FIG. 1. Acute gonococcal epididymitis.

inal vesicles which have become infected are unable to drain through the swollen and occluded ejaculatory ducts, converting the vesicles into infected retention cysts. The front door is blocked and the vesicles are overdistended and the infection spreads through the back door, the only means of egress, into the epididymis. The dull pain and aching in the groin which usually precede clinical epididymitis can be attributed to the increase tension in the vas. This generally disappears when the epididymis becomes involved, the infectious processes having locked themselves in the tail.

Inflammatory swelling follows the infection and occludes the tubules at the junction of the tail and vas, which, may be recalled, is an acute angle and drainage is stopped. At the junction of the upper end of the tail with the body, the upward

extension of the process within the tubule becomes blocked as a result of the inflammatory swelling and the anatomical fault previously described, and the infection is locked in the tail. This accounts for the fact that gonococcal epididymitis is practically never an epididymo-orchitis, but a pure epididymitis, limited to the tail. There is little, if any, involvement of the testicle or body or head of the epididymis. Hagner<sup>10</sup> in a series of more than 200 cases of gonococcal epididymitis, operated upon, never found evidence of involvement in the testicle itself.

Rolnick<sup>8</sup> has failed repeatedly in attempting, with either low or high pressure, to force fluid beyond the tail of the epididymis, through the vas. This method of spread has also been proved by the injection of solutions into the ejaculatory ducts and seeing them appear in the vas; also in Belfield's<sup>9</sup> experiments in seeing urine appear in vasotomy wound.

The tension increases and inflammatory reaction in the surrounding tissues becomes marked, a periepididymitis, the infection being carried *peritubular*, rather than *intratubular* to the rest of the epididymis. Cunningham<sup>10</sup> has never observed the testicle to be involved except by extension of the epididymal congestion over its surface. With increasing intensity of the infection, the tunical vaginalis, dartos and even the skin become involved through direct extension, causing the tail to become adherent to skin and filtration of the vas. Ingram<sup>11</sup> reports 3 cases of suppurating gonococcal epididymitis which ruptured, Kalopp<sup>12</sup> reports a case of atrophy of testicle following gonococcal epididymitis.

With the beginning of involvement the discharge may subside or even disappear at the meatus; there is an amelioration of symptoms, probably due to the fact that the ejaculatory ducts have become patent and the vesicles drain, and that the mobilization of the defense mechanism has shifted from the epididymis to the urethra. The epididymitis sometimes may be credited with having accomplished indirectly

what treatment has been trying to accomplish, cure a gonococcal infection. We certainly know that some cases present no further evidence of gonococcal infection. The reappearance of a discharge does not indicate that the epididymis is draining out through the vas and through the urethra, because in the majority of cases the epididymis has become occluded. Even after the periepididymitis becomes resolved, the body, etc., returning to normal, the tail remains hard and infiltrated as a stigmata of infection. If abscesses are present, they are generally found around the tail, and even if found around the body or head they are to the outside. Hydrocele to a marked degree may form, generally subsiding but in many cases persisting and increasing. We have seen one such case, bilateral, massive and requiring numerous paracentesis and later operation, a photograph of which is here shown (Fig. 1).

#### CLINICAL COURSE AND SYMPTOMATOLOGY

The symptomatology is typical and clear and well known: fever; often chills; faintness; a sickening pain in the testicle; marked tenderness, often most severe along the spermatic cord or referred to the lower back, often appearing before the stabbing, agonizing pain in the testicle, very sensitive to even the most gentle touch. Cord pain is due both to the drag of the swollen testicle as well as the swelling in the funicular sheath. It may be overshadowed by intense pain in the epididymis. The cord is often felt as a thickened cord. Pain is increased by motion. In many cases the symptoms are not so severe, merely a slight discomfort or pain on handling the testicle. There is in a large percentage of cases a cessation of the discharge from the urethra as mentioned previously.

Many patients take to bed of necessity, but a considerable number continue work. The active clinical course varies from one to three weeks. Prognosis is good, except for subsequent sterility. There generally remains a thickened, infiltrated and oc-

cluded organ. Epididymitis is the most frequent inflammatory cause of male sterility.

Wade<sup>13,14</sup> classifies the different clinical stages of gonorrheal epididymitis briefly about as follows:

Stage 1: Pain in the groin and along the course of the vas deferens and a feeling of discomfort.

Stage 2: The epididymis has become involved and there is swelling, tenderness and pain along the course of the vas, and general malaise.

Stage 3: There is considerable swelling of the epididymis with increase in the severity of the symptoms.

Stage 4: The epididymis is enormously enlarged, with a marked periepididymitis, involvement of the scrotum, and hydrocele makes its appearance. There is often high fever, toxicity and intense suffering.

Stage 5: This is the stage of resolution with gradual disappearance of exudate but often increased fibrous changes at the tail. The symptoms gradually cease.

#### DIAGNOSIS

The diagnosis is usually made by the patient and if not is readily made by palpating the acutely tender and swollen epididymis, often with a swelling and reddening of the scrotum, even becoming tense and shiny. If the case is seen early there may only be a funiculitis or involvement of globus minor and no periepididymitis. In the presence of hydrocele there may be some question; but the presence of an acutely tender hydrocele means an acute epididymitis is present. If there is a urethral discharge present and a smear shows the presence of an intracellular diplococci, the diagnosis is proved. There are cases that show neither a urethritis nor a history of antecedent urethritis; and there are other cases that occur without marked tenderness or systemic manifestation that often raise a question in our minds.

There is another group of cases that may puzzle us. This is the group that remain

in a subacute stage for some weeks, often raising the question of tuberculosis. Acute onset sometimes characterizes cases of tuberculous epididymitis and may be clinically indistinguishable. The mistake is usually made in diagnosing such cases as tuberculous. In tuberculous epididymitis there is a more gradual onset and generally the condition has existed for sometime before the patient seeks treatment. Kretschmer<sup>15</sup> found in 85 cases of tuberculous epididymitis that 70 cases showed changes in the prostate and vesicles. In 75 cases, 79.8 per cent showed either clinical or x-ray evidence of pulmonary tuberculosis. Stevens<sup>16</sup> points out that bilateral involvement favors tuberculosis and that scrotal sinuses of more than a month's duration are probably tuberculous.

The differential diagnosis between a gonococcal epididymitis and a non-gonococcal, non-tuberculous epididymitis may be difficult in the absence of an urethral discharge or if a discharge is present, absence of gonococci, or if the epididymitis precedes the urethritis. If a predominance of pyogenic organisms, other than the gonococcus, are found in the smear and there is a negative history of gonococcal infection, we may assume that the case is non-gonococcal, non-tuberculous.

Torsion of the cord may simulate an acute epididymitis, but it is rare and there is the absence of other clinical data. Luetie epididymitis is very rare; generally it is an orchitis, without an acute history. Rolnick<sup>17</sup> reports 3 cases secondary to or associated with orchitis. It more nearly resembles tuberculous epididymitis and the head is always affected.

#### TREATMENT

When we consider the modern conception of the etiology of gonococcal epididymitis, mechanical transfer of the gonococci-laden material from the posterior urethra to the epididymis, there is offered to us a definite program for prevention. In the presence of a known active gonococcal infection the patient must be warned not

only against sexual intercourse, but against sexual excitement, "petting"; heavy lifting, particularly with a distended bladder. If there is an acute posterior gonococcal infection, no injections or irrigations should be used until the acute inflammatory reaction subsides and even when injections are started they should be gentle and irrigations should be given with low hydrostatic pressure only. Of course, no instrumentation should be done as long as gonococci are present. No massage of the prostate or stripping of the vesicles should be performed until all acute symptoms have subsided.

Yet, despite these precautions, epididymitis will occur. When it has developed, how shall we treat it? The main factors in the treatment are:

1. Alleviation of pain and swelling and relief of systemic manifestations.
2. Prevention, if possible, of occlusion of the ducts and thus the prevention of sterility.
3. The eradication of all gonococcal infection in the genital tract.

The treatment of epididymitis has been varied and often a source of disappointment to patient and physician alike. A host of therapeutic measures have been advocated, indorsed and discarded; testicular supports; vaccines, stock as well as autogenous; scrotal irritants, such as 50 per cent guaiacol in glycerine or ichthyol ointment, etc.; modified constriction hyperemia, produced by rubber bandage compression and diathermy more recently; non-specific proteins; turpentine injections and the intravenous injections of mercuriochrome-220 soluble, sodium iodide and later calcium chloride.

Calcium chloride has been advocated by Leff and Spencer,<sup>18</sup> Rupel,<sup>19</sup> Cerf<sup>20</sup> and Wade,<sup>3,4</sup> on a basis of increasing phagocytosis and reducing inflammation in the tissues. We regret to say that we have not given this method a trial. It did not appear rational to us. Wade<sup>3,4</sup> states that in the early stages of epididymitis, putting the patient to bed, applying ice and bags

giving intravenous injections of 15 grains of calcium chloride daily, along with vas injections will often abort a case. Rupel<sup>19</sup> treated 28 patients with an average of 4.1 days in bed and 22 cases of the 28 were treated in the office. Cerf<sup>20</sup> concludes after its use, "it has a decided effect in causing rapid subsidence of swelling and in hastening absorption."

We gave sodium iodide intravenously rather than an extensive clinical trial, but failed to be impressed with its use, despite the claims of my good friend Dr. Louis T. Wright<sup>21</sup> of Harlem Hospital, New York, Hutchinson<sup>22</sup> concludes that next to operative treatment, sodium iodide is most effective. Ravich,<sup>23</sup> Stern and Ritter<sup>24</sup> draw similar conclusions. There certainly is no real scientific indication for its use and we abandoned its use some years ago. The results were very variable with abject failure predominating.

In 1924, Wren and Tenenbaum,<sup>25</sup> in a series of 100 cases, used turpentine injections in 0.5 c.c. to 1 c.c. of 20 per cent emulsion of rectified oil of turpentine in sterile olive oil. The injections were given according to the original technique of Klingmueller.<sup>26</sup> The site of injection is the point of intersection of a line drawn from the posterior axillary border and a line figured two finger-breadths below the brim of the pelvis. At the intersection of these lines the needle is thrust in until it strikes the periosteum of the bone, upon which the injection is administered. We used this injection in 21 consecutive cases and the conclusions of Wren and Tenenbaum were substantiated. The relief of pain and involution of the scrotal contents were striking, generally all pain and fever disappearing by the following day when the testicle could be compressed without causing pain within at least forty-eight hours. There was but little effect in our series in the disappearance of the urethritis. We were forced to abandon this method of treatment because of the increasing number of patients who, while having the pain in the scrotal

relieved, complained of pain and numbness in the hip, radiating down into the leg. One patient limped for three days. Apparently my technique was faulty, but we could not seem to correct it. Of all methods of conservative treatment this one allowed massage of the prostate earliest, generally within two to three weeks after last injection, thus eradicating a potential source of reinfection.

We have recently been using, in combination with other routine methods a non-specific protein injection, in 10 c.c. intramuscular injections at two to three day intervals. The intramuscular use was advocated by Muller and Reese,<sup>27</sup> Blamou-tier<sup>28</sup> used milk injections and feels it shortened the course and allowed urethral treatment earlier. As a rule pain disappeared within twenty-four hours, not quite as dramatically as with turpentine injections. Campbell<sup>29</sup> in a series of 50 cases could demonstrate no particular value. We found it had little or no effect on the urethritis.

Diathermy has been very favorably advocated by Corbus and O'Connor.<sup>32</sup> Some of my colleagues speak very highly of its analgesic effect and its effect on resolution, while others see no marked advantages. Campbell<sup>29</sup> could see no marked advantages over his adhesive suspensory. We have had no personal experience with diathermy.

Meridith Campbell<sup>29,30,31</sup> of Bellevue, who has made such an extensive study of epididymitis, having studied 3000 cases, believes that splinting of the scrotal contents causes the most rapid relief of pain, almost immediately. He puts the patient to bed, splints the scrotal contents according to an adhesive plaster method used at Bellevue and later to be described. He applies an ice bag. He found that in 50 cases treated without adhesive suspensory and with ice bag alone, pain remained

<sup>1</sup> Since the writing of this paper a personal communication from Dr. A. A. Wren, informs me that he and his associate had also abandoned "turpentine injections," some time past, for the same reasons as stated here.



longer. In 100 cases treated with the suspensory, the results were equally as good with or without ice bag.

Cases treated by me with vaccines seemed but little influenced.

It is not in the mild cases that treatment has been unsatisfactory but rather in the severer types, beginning with high fever, severe pain and marked systemic manifestations. This form has enlisted all the skill and ingenuity of the physician. Eric Stone<sup>33</sup> in a recent paper makes an analysis of 215 consecutive cases, comparing the results of various treatments. He makes in substance, the following conclusions:

1. Expectant treatment alone is insufficient.

2. Epididymotomy gives immediate relief of pain in a large number of cases; shorter time of incapacity, about one-half the time, compared with expectant treatment; and shorter time of involution except with non-specific protein injection. It lowers the percentage of recurrences, except that it is excelled by mercurochrome—220 soluble.

3. Sodium iodide intravenously gave poor results.

4. Non-specific protein injection stands next to epididymotomy in relief of pain and is more effective than any other agent in shortening the stay in the hospital.

5. Mercurochrome-220 soluble is next to non-specific protein injection in relief of pain.

6. Diathermy, if the cases are seen early may prevent any incapacity, but does not affect the pain.

The question when to use surgical treatment is often difficult to decide. Cunningham<sup>10</sup> believes epididymotomy offers the best means of treatment and he operates in most of his cases. Hagner<sup>34</sup> whose operative technique for epididymotomy is almost universal, believes that only the severe cases should be operated. Campbell<sup>29</sup> advocates epididymotomy in cases that have pain persisting after forty-eight hours, after rest in bed, scrotal splinting and ice

cap and also in cases of painful chronic epididymitis and recurrent cases. Wade<sup>3,4</sup> believes that in cases of epididymitis with advance inflammation, cases in his group 4, epididymotomy should be performed in the first four or five days and thus sterility can be prevented. Allen<sup>35</sup> advocates early epididymotomy for the following reasons:

1. It shortens the time of disability.
2. It gives complete relief from pain.
3. There is immediate relief from toxemia.
4. There occurs a minimum destruction of healthy tissue.
5. There is a total absence of recurrences.
6. The procedure is simple and quick, usually taking about five minutes after the patient is anesthetized.

Pelouse<sup>2</sup> does not believe that the end-results of surgical treatment have been any better than the non-surgical methods, despite its widespread popularity. Cases developing definite abscesses of the epididymis demand surgical drainage, but there is no need for epididymotomy to become a general procedure. We are heartily in accord with this position. In my series of cases, there were 2 with marked tension of scrotal contents; we performed aseptic aspiration with a wide bore needle fitted upon a record syringe, with marked relief of pain and early resolution.

#### EPIDIDYMYTOMY

The operation of epididymotomy according to the Hagner<sup>34</sup> technique is the one generally used. He believes that it is only indicated in the graver cases. It is based upon the simple principle of drainage. The technique has been so well standardized and so often described that we shall do no more than show its technique in the film to follow this discussion. Belfield's procedure of vasotomy is often combined with epididymotomy. Cunningham's<sup>10</sup> cases did not show results different from those in which operation was not done. It must be remembered that curing the epididymitis is often simple compared to the eradi-



cation of the gonococcal infection in the prostate and seminal vesicles. They must receive appropriate treatment. Epididymotomy certainly allows early follow-up treatment.

Epididymectomy should be restricted to cases of remission after epididymotomy, in cases of long-standing, tender, bilateral epididymitis. We recently recommended epididymectomy in such a case in a man past fifty who has had recurrent bilateral epididymitis and a constant dull pain and tenderness in both epididymi for one year and frequent flareups with urethritis from which gonococci can be cultured.

The procedure that we have employed in our most recent cases is about as follows:

We believe that by far the greater number of cases can be treated ambulant. If the disease is very acute we generally put the patient to bed for at least two or three days. The patient is given a cathartic, abundant fluids, and the scrotal contents elevated by the adhesive suspensory advocated by Campbell<sup>29</sup> and perfected at Bellevue Hospital; and an ice cap is applied. If the ice is not tolerated, hot moist magnesium sulphate solution compresses are used. Non-specific protein injections, 10 c.c. intramuscular, are given in the gluteal muscles every day until pain, tenderness and fever have subsided; usually 4 or 5 injections are sufficient. Some sort of ambulatory scrotal support is used for at least the duration of the treatment. The ordinary jock-strap with the scrotal contents pushed forward by a nest of cotton is good.

As has been indicated, it is very necessary to eradicate all gonococcal infection. If there is a discharge we institute personally administered urethral injections of one of the silver salts at about the second week and at the third week we do not hesitate to give irrigations, with low hydrostatic pressure, at the height of about 2 ft. Massage of prostate and stripping of the vesicles are begun as soon as the

urethritis has cleared up and the gonococci have disappeared. This treatment is continued as described in a previous communication<sup>5</sup> and the same standard of cure adhered to as advocated in a previously published paper.<sup>36</sup>

#### CONCLUSIONS

1. Gonococcal epididymitis is the most frequent disease of the testicle and the most prominent cause of male sterility.

2. Chemical irritation; instrumental trauma; and sexual excitement with an overdistended bladder in the presence of either an active or latent gonococcal infection, are the most common causes of epididymitis.

3. Epididymitis is the result of a mechanical transference of gonococci-laden pus from the posterior urethra and seminal vesicles down the vas to the epididymis. It is peritubular extension and not intratubular, involving principally the globus minor and the other portions of the epididymis by periepididymal extension. It is a true epididymitis and not an epididymo-orchitis.

4. Prevention may be achieved by rest, physical and sexual; gentle and skillfully applied urethral medication in the presence of gonococci, and gentle prostatic and vesicular massage and instrumentation in latent infections.

5. Our clinical experience leads us to believe that in the vast majority of cases conservative treatment, rest, scrotal splinting, intramuscular injections of non-specific protein injection will yield good results, many cases remaining ambulant. Operative treatment is indicated in the fulminating cases not yielding to conservative treatment and in recurrent cases and in cases not resolving.

6. Thorough eradication of all foci of infection in posterior urethra, prostate and vesicles is necessary, regardless of type of treatment employed.

[For References see p. 482.]



# THE PRESENT STATUS OF UNCOMPLICATED GASTRIC AND DUODENAL ULCER\*

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THE discussion will be limited to cases of non-specific uncomplicated ulcer of the stomach and duodenum; that is, no case of tuberculous, syphilitic or other extraordinary infection will be included; nor any case of ulcer, complicated by hemorrhage, perforation or anatomical stricture or distortion.

The whole cycle of experimentally produced peptic ulcer in animals has again been thoroughly reviewed in the last few years by Kirch and Stahnke, Wolfer, Caylor, Crohn, Weiskopf and Aschner, and Mann and his co-workers, from the first break of the mucosa with hemorrhage and destruction of the epithelium to the covering of the scar-filled defect. The important fact which has often been emphasized is the rapidity with which gastric defects heal. Clinically this laboratory fact should be associated with the rapid regression of ulcers in the intermission periods. This may possibly explain an occasional case of negative finding at exploratory laparotomy in cases with suggestive ulcer history and positive physical and laboratory data. For instance, in a series of such cases reported by Crohn, Weiskopf and Aschner, in which a second exploration was done at a later date during a recurrence of the symptoms, the patient showed definite ulcer.

In summary, it may be said that pathologically peptic ulcer is an inflammatory lesion so situated that gastric juice has possibly something to do with the destruction of excessive amount of tissue. That the inflammation is primary is strongly suggested. Various predisposing causes seem to be operative in the patients, but these are not conclusively established. The direct exciting cause of ulcer has, however, not yet been disclosed in such a fashion as to be

beyond doubt. The persistence or chronicity of the ulcer depends on a variety of factors none of which can be said to operate in all cases. Probably several of these factors are coincidentally in evidence. Thus, there must be considered especially hyperacidity, stasis of neuromuscular or obstructive origin, the irritative and traumatic influence of gastric contents, and the traction of muscle about the ulcer.

Von Bergman's spasmogenic theory of ulcer as studied by Nakashima does not seem to me to have much etiological importance. Personally I have always felt that spasmogenic manifestations have been "accessories after the fact," results and not causes of ulcer. Experimental work on the subject has given very divergent results which do not by any means always support the neurogenic theory. In Schmid's studies none of the findings indicated did damage to the nerves with certainty. McCrea's evidence shows: (1) That the anatomical distribution of the nerves to the stomach is sufficient to account for instances of reflex spasm or of incontinence of the pylorus in the case of gastric or duodenal ulcer, and of spasm or of atony of the body of the stomach with duodenal ulcer; (2) that the "ulcer-bearing" area of the stomach corresponds to the area in which the nerve branches are chiefly grouped; (3) that local spasm with resultant anemia is a probable cause of the chronicity of ulcer, aided by factors such as retention and infection set up by reflex spasm; (4) that certain of the "gastric neuroses" may be exactly simulated by the resection of either the vagi or the nerves; (5) that the results of nerve stimulation and therefore of nerve irritation can also simulate certain of these "neuroses"; (6) that the phenomena grouped under the title of

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the "nervous dyspepsias" or "gastric neuroses" may have at least three sources of origin. These sources are: (a) peripheral irritation of the nerves, manifested by gastric signs and symptoms; (b) lesions of the nerve paths; (c) central disorders, possibly of endocrine origin. Such secondary phenomena probably account for those forms of acute pyloric obstruction which occur in the presence of an old pyloric stenosis as described by Delore, De Rougemont and Greysel.

I shall not say very much about the question of gastric chemistry inasmuch as it will be found necessary to go into this more fully and to the point in a subsequent part of my discussion. Suffice to say here that ulcers while usually existing in a condition of increased gastric acidity are also nevertheless found in conditions of lessened or absent acidity and that in the postoperative periods an immediate fall of acidity should be held in question until the permanent effects of the operation are demonstrated. This is so because some work of mine which was published about ten years ago showed conclusively that immediate effects are often most temporary.

Recent studies are making us return to the old inflammatory theory of Cruveilhier. Duval and his co-workers are impressed with the importance of this factor and describe how infection modifies the clinical symptoms and the histological and biological findings of all forms of ulcer including even those of perforated ulcer. These studies are confirmed by those of Konjetzny. In all cases of ulcer Konjetzny, Orator and Kalima have found a gastritis localized chiefly in the pyloric antrum. This observation has been confirmed by Bohmansson's findings in freshly resected specimens. In the more chronic, plasma cells and regressive changes are predominant, whereas in more recent cases and in acute exacerbations in chronic cases additional leucocytes in great numbers and not infrequently suppurative processes in the mucous membrane and miliary abscesses are found. The constant presence of plasma

cells even in acute ulceration of the mucous membrane with hemorrhage indicates that the gastritis is older than the ulceration. In all probability the inflammation in the pyloric part of the stomach is primary and constitutes one, and perhaps the most important, factor in the so-called gastric ulcer diathesis; in cases of chronic ulcer diathesis. In cases of chronic ulcer with acidity there is generally a condition of atrophic gastritis with increased connective tissue formation and glandular atrophy. In cases of acute ulcer the inflammation is not intense. The varying degrees of acidity may possibly have something to do with the different stages of gastritis.

Each year the subject of gastritis assumes a larger importance especially in its relations to gastroduodenal ulcer and to its consequential phenomena after stomach operations for ulcer. Certain clinical observations also indicate that the inflammatory phenomena are not always to be considered solely as secondary processes, and Duval believes that secondary infection of this kind is present in only about one-third of the cases of gastroduodenal ulcer. Microscopic examination of his specimens corroborates this assumption and the cultures yield streptococci or enterococci.

It should therefore be remembered, as a practical fact, that a chronic gastritis forms an important part of ulcer, and Korbach has been able to see and treat this inflammatory condition through the gastroscope. According to Monsarrat, a specific organism is not essential for this association. As will be seen later this viewpoint has important bearings on the therapeutics of ulcer.

In deciding the question of medical or surgical treatment in any individual case there are many factors to be considered. In any case the economic status of the patient is a matter of great importance because medical treatment requires long-continued and tedious management and surgical treatment must be followed by a long period of medical care.

The social and biological characteristics of the class or group in which the individual patient belongs are also of extreme importance and will strongly influence the patient's reaction to the medical or surgical means employed to combat this most refractory of diseases. The capabilities, the knowledge and the technical abilities of the surgeon personally responsible for the management of the case are of paramount importance when the question of surgical therapy is considered and no one in justice to the individual patient should be selfish enough to exaggerate his own abilities when deciding upon the actual type of operative interference to be selected. All of these factors go hand in hand to the greatest extent with the particular environmental factors which characterize individual clinics.

Lahey among others, is convinced that gastric and duodenal ulcers are in no way primarily surgical diseases. They become surgical only when they have been demonstrated to be non-medical in the course of medical treatment. He believes it to be unjust to subject patients with ulcer to surgery without a careful trial of medical management and in this he but repeats what everybody else has said for the longest time. Because of the postoperative complications of gastroenterostomy, such as jejunal ulcer, the higher mortality of partial gastrectomy, and the uncertain future for the achylie stomach, the surgeon operating for peptic ulcer should be certain that a thorough pre-operative medical regime has been tried. Lahey uses the Sippy plan of treatment, and hospitalizes the patient for three weeks if necessary. During this time the diagnosis is established, relief of symptoms is obtained, and the patient is taught the dietary routine he must follow for the coming year. The cat in the bag with this line of treatment, however, is that it is not always as easy as it seems. Such courses of treatment take a well-lined pocketbook and plenty of leisure time. For the working

man or the one with moderate income it is frequently impossible.

The special indications for medical management of ulcer are:

1. Poor surgical risks in which the immediate danger to life is greater with surgery than with medical management.
2. Ulcers located on the upper border of the cardia near the esophagus where excision seems to be difficult.

The indications for operation in cases of ulcer of the duodenum depend upon several factors. (1) The length of time the symptoms have been noted should be considered; if the symptoms have been present a long time, and especially if the patient has had several periods of good dietary management without relief, operation should not be postponed. If the symptoms have been present for only a short time non-surgical treatment should be instituted at once as there is plenty of evidence to show that dietary management started before the condition becomes chronic may result in complete relief of symptoms and the healing of the ulcer. (2) The age of the patient should be taken into consideration; a young person with mild symptoms of short duration should be placed on a dietary regimen for a considerable period. In any case the severity of the symptoms will help to determine the plan to follow because if there is a constant tendency toward perforation, bleeding or severe gastric disturbances not quickly relieved by diet, operation is indicated. In all cases of duodenal ulcer diet should be tried before operation is considered. It is a mistake, however, to continue dietary treatment if nothing is being accomplished by it and if the symptoms return following the least indiscretion. Many duodenal ulcers, even though chronic, run a mild uncomplicated course so that the patient may be treated medically with the idea of eventually resorting to operation if the result of the non-surgical treatment or the cooperation of the patient is unsatisfactory. Duodenal ulcer is a common lesion. Between 1200

and 1500 patients thus afflicted are seen in the Mayo Clinic every year, but only about 65 per cent of the patients with duodenal ulcer who enter the Mayo Clinic undergo operation.

Although there seems to be almost universal agreement about the advisability of subjecting patients to medical treatment at first, especially those with duodenal ulcer, the astounding thing about this attitude is that one detects very easily underlying the discussion the lack of confidence which everyone has in the possibility for permanent cure of medical courses of treatment. I myself am inclined more and more to believe that the medical cures of gastric and duodenal ulcer are really not cures but remissions of symptoms or temporary closures of ulcerated areas, which at the slightest provocation owing to the underlying "ulcer" susceptibility, will reopen again in the same or in new locations.

I say this advisedly in spite of the fact that I have repeatedly seen on the operating table the scars of healed lesions in the stomach wall which almost invariably are ordinarily taken to be healed ulcers. I believe that many of these healed lesions are merely in a temporary state of healing; or that they are the results of embolic lesions in which the underlying "chronic ulcer" cause is not present. I have spoken of this conception on several different occasions. Given a lesion of this kind it would be idle and ridiculous to attempt surgery when it is the rule to expect permanent healing after almost any kind of conservative treatment. This is probably the source of all medical cures.

There seems to be entire agreement among medical and surgical men that when medical forms of treatment fail and are inefficient, then one should unhesitatingly resort to surgery. But here the trouble begins and there is an entire lack of harmony among different men both in the same and in different localities as to the effectiveness of any form of surgical procedure for uncomplicated ulcer, (except

in the one form of non-ulcerated pyloric stenosis by scar contraction, for which gastroenterostomy is the standard treatment).

The conviction has been spreading that progress in the management of peptic ulcer will depend on a more intelligent selection of cases for operation and a better appreciation of the general principles of those operations which experience has shown to be worthy of application. The selection of the operation depends upon many factors, the chief of which are the condition of the patient, the stage of the disease, the situation and character of the lesion, and the complication associated with it. (In Judd's opinion, the present enthusiasm for resecting the stomach for duodenal ulcer will not last very long.)

It would be idle to go through the great number of published reports which have appeared during the last year or two with their masses of statistical information and personal impressions inasmuch as it does not add to one's information; any individual year's crop of literature usually repeats more or less that of former years. The impression which is conveyed is that the entire discussion boils itself down to the choice between the various forms of gastrojejunostomy and of pyloroplasty and some form of extensive resection of the stomach.

This choice seems, however, still to be one of the most difficult there can be. In many American (Deaver, Pool, Peck, Woolsey, etc.) and English (Sherrin, Walton, etc.) quarters, gastrojejunostomy is still the operation of choice, but there is a tendency in other quarters (Pamperi and Schwartz from Schloeffler's Clinic in Prague, Starlinger from Ranzi's Clinic in Vienna and Innsbruck) to appreciate the fact that as time goes on the gastrojejunostomy cases tend to grow worse, whereas the resection cases show the tendency to get better and better.

In the immediately preceding years there has been brought out the important fact that the trouble with gastrojejunostomy is that in many of the patients, and the proportionate number varies widely, a

recurrence of symptoms takes place which is almost invariably due to the presence of a secondary ulceration in the neighborhood of the stoma. Everyone agrees that the secondary ulcers occur; but the difference in weight which is given to this accident varies widely in different clinics owing to the apparent differences in the percentage number of cases. The variation extends from relative indifference to an attitude in which gastroenterostomy is recognized as a disease per se. Those who report small numbers of such secondary ulcers put the onus of the larger percentage reported by the others on various factors which to my mind appear trivial except for the one factor which concerns itself with the different type of human material upon whom the operation of gastrojejunostomy is carried out.

In America, this factor has only lately made itself apparent. It has been emphasized by the large number of secondary peptic ulcers which have been reported as occurring in Jewish patients (Lewisohn's report from the Mount Sinai Hospital service of Berg). In the Mayo Clinic (C. H. Mayo) it is believed that this large percentage has intimate relations with the racial characteristics of the Jewish people. But in widely different parts of the world, Bastianelli (Italy); Haberer, Finisterer, Koenig, etc., (Germany); Hartman, Duval, etc., (France); Ranzi, von Eiselberg (Austria); Arn, Deaver, etc., (America); Starlinger (Innsbruck); Grekov (Leningrad); Urrutia (Spain); Moynihan (England); Lengemann, Schwartz, etc., reports are forthcoming from sources in which this factor does not enter; and in these, nevertheless, the numbers of secondary ulcers have been large enough to cause the abandonment of gastrojejunostomy. At the meeting at which Berg reported his results of gastric resection in which the subject of secondary ulcer was discussed, one of the men (Russell) intimated that possibly the small number of recurrences which their men reported were due to inefficiency of the given follow-up system which was employed.

Nevertheless the men (Sherrin, Pool, Flint, Deaver, W. J. and C. H. Mayo, Balfour, Peck, Galpern, Schuyzer etc.) who prefer gastrojejunostomy, hold tightly to their preference; as a matter of fact, just as tightly as do those (Haberer, Finisterer, Berg, Lewisohn, Duval, Eiselberg, Grekov, etc.) who would abandon the operation for the larger resection. I think possibly just at present the balance of the scale is a little in favor of the resection operation. And I really believe, that were it not for the larger mortality of resection operations in less experienced hands, and the lack of confidence of many surgeons in their ability to make a good showing with gastric resection, that the larger type of operation would, for the present at least, advance in favor with leaps and bounds. This is possibly the cause for the recent tendency to conservatism on the part of some, notably, Bier, Kuttner, and Payr.

It seems to be almost an unwritten rule in medicine and surgery that no one procedure is applicable to all cases of any given entity; and, in many quarters, (Gilbride, Lahey, Horsely, Finney, C. H. Mayo, Woolsey, Pamperi and Schwartz), the rule is made to apply to ulcer cases. However, at Finisterer's Clinic, and at the Mount Sinai Clinic (Berg), resection is done as a routine measure on all patients who apply for relief of ulcer without regard to any of the factors upon which and because of which in other clinics a selection is made from the available procedures; other things being equal, I should myself lean to the resection form of operation.

The rationale of the resection operation as practiced for gastric ulcer is not the same, however, in the various clinics. In the German clinics (Finisterer, Haberer, etc.) the purpose of the resection is to remove so much of the stomach wall as to reduce the acidity of the stomach contents to as near zero as possible; the American school (Berg, Lewisohn etc.) follow the German line of reasoning. In



the French School (Duval, Hartmann, etc.) the purpose of the resection is to move the focus of infection in the stomach wall (gastritis, etc.) as completely and as radically as if one were operating for malignancy, inasmuch as it is believed that infection and not acidity is the dominating factor in producing secondary ulcer. In the American School (Lewisohn) it is, however, recognized apparently that infection (gastritis) plays some part in the total pathologico-clinical picture, because the purpose of doing resection of the body of the stomach in duodenal and other forms of non-resectable ulcer after the manner and method proposed by Finisterer, is said to be not only for the purpose of decreasing the acid-producing part of the stomach but to remove an abnormal wall which is the only seat of a gastritis of greater or lesser extent.

Recognition of the importance of gastritis also as a potential source of disaster in the surgical management of ulcer is stressed also by Gregoire and Bohmansson. There are periods in the course of a gastric ulcer during which there is a distinct exacerbation of the infective process. These are characterized by an elevation of temperature, which may reach 39°C. or more, a corresponding elevation in the pulse rate, an increase in the intensity and duration of the pain, and the occurrence of gastric hemorrhages. Operative interference during such periods is attended by the gravest danger because of the tendency of the manipulations to disseminate the infection. Surgical measures should therefore be delayed until the crisis has entirely subsided.

It is for this reason that Duval's contention seems correct that limited resection of the stomach has a higher mortality than extensive resection or gastropylorctomy because the former may be performed in infected tissue whereas the latter are done outside the limited zone of infection. Nicolaysen goes even further and believes that operation for gastric ulcer should not be performed in the period of infection.

When infection is suggested, specific vaccination should be done until the biological tests become normal. If an emergency operation is necessitated by complications, it should be extensive enough to be performed outside the infected zone. On the basis of histological studies these viewpoints are confirmed by Kalima and wider excisions are recommended.

The actual method of doing the gastric resection seems of no great importance. A number of methods (Polya, Hoffmeister, Schumaker, etc.) have been described as so-called new methods and several (Hoffmeister, Polya) of them have come into prevalent use. Nevertheless, the time-tried Billroth types of operation both 1 and 2 seem to hold their own very well, and, of these two, the type 2 is the easiest to perform while the type 1 is the best if the technical conditions in the operative field form no insuperable obstacle.

I get the impression that except for very few clinics the exclusion form of stomach resection for duodenal and other non-resectable forms of ulcer has not gained many adherents. The report of Schomberg from Floerken's Clinic is not very impressive. Judd is of the opinion that the present enthusiasm will not last.

Reports of the bad results which have followed the various forms of minor operation, gastroenterostomy especially, have been increasing in number. To quote a few of these: Finisterer, of Vienna, during a visit to this country in the fall of 1923 quoted the following statistics: Payr had in his material 62 per cent recoveries and 38 per cent failures; Bier 66 per cent and Haberer 37 per cent recoveries. Many reports from the French clinics also show unsatisfactory results. The series of statistics giving the worst results after gastroenterostomy published by an American surgeon, are those reported by Lewisohn from Berg's service at Mount Sinai Hospital. He reports that 34 per cent of the patients have gastrojejunal ulcers. This latter group of statistics is the basis for

the advocacy of the more radical subtotal gastrectomy.

The mortality of the exponents of resection as a substitute for gastroenterostomy is usually represented by those of Moynihan, Haberer, Finisterer, and perhaps others who have achieved a mortality of 2 to 3 per cent. It is proper, however, to emphasize the fact that such a mortality only prevails in the hands of expert operators, and under the most favorable conditions. In the hands of those not especially trained the mortality is doubtless a high one. It is, indeed, very interesting that most of the support in favor of resection comes from the internist. Many physicians who have had occasion to compare the permanent cures following resection of the stomach with the many failures following simple gastroenterostomy are strong supporters of the resection. The cooperation of internist and surgeon in the preoperative preparation of the resection patients has strikingly contributed to reduce the surgical mortality.

Preoperative factors enhancing the surgical end-results are the proper selection of the cases both from a general and a special standpoint, and from the complete examination of the patient. Increasing knowledge concerning physiological gastric types and their variations and mode of response to treatment, furnishes criteria for the proper selection of the individual operation. The patient who has been well chosen and skilfully operated on very often does well even without any exact postoperative regimen.

*Secondary and Gastrojejunal Ulcer.* The biggest problem today in gastroduodenal ulcer is that of the secondary (recurrent gastrojejunal or jejunal) ulcer. Recurrence of ulceration may follow any operation for peptic ulcer. The incidence of jejunal ulcer in many large series of cases, like those of the Mayo Clinic, Moynihan, Sherren, Walton, etc., is 2 per cent or under. Koennecke and Jungemann report 4 per cent in the Goettingen Clinic. In the German literature estimates are as high

as 3 per cent. In Woolsey's series there were less than 2 per cent. In contrast to these, Lewisohn among 68 patients traced four to nine years after gastroenterostomy for duodenal ulcer, found 18 per cent of jejunal ulcers corroborated by operation, and 16 per cent more, diagnosed clinically and by roentgen-ray, a total of 34 per cent. A. A. Strauss reports 20 to 30 per cent of jejunal ulcers after gastroenterostomy and says that Karl Meyer found 25 per cent at the Cook County Hospital. These figures suggest some special factors to account for them in addition to the causes of jejunal just mentioned.

It has been stated in the American and English literature that gastrojejunal or jejunal ulcer followed gastroenterostomy in 1 to 3 per cent of cases. In the German literature this was estimated to occur in from 5 to 10 per cent of cases and several years ago Lewisohn reported the astounding number of 34 per cent. This number of gastrojejunal ulcers and the reported poor results from the foreign clinics caused the advocacy of more radical treatment of duodenal ulcer. Haberer was one of the first to use extensively the method of pyloric resection for duodenal ulcer, performing the anastomosis, a gastroduodenostomy, by a modification of the Billroth I method. This procedure was adopted by many European surgeons. Finisterer advocated and practiced a resection of from two-thirds to three-fourths of the stomach. Radical operations were becoming the fashion of the day.

Major resection operations are also proving no exception to the rule and as the result of the wide enthusiasm for resection, operations are coming to be counted secondary and gastrojejunal ulcers are being reported with apparently increasing frequency. Cole and Hognuet have reported a large marginal ulcer after Polya operation, (Lewisohn 3 cases following Billroth 2 operations). Finisterer reported 29 cases after the Haberer operation; Friedmann 21 cases; and at the Russian Surgical Congress Sokolov reported that



4.3 per cent of the gastrectomy cases were followed by gastrojejunal ulcer. Some of the latter occurred as late as seven, nine, twelve and twenty-five years. In Borger's case, resected by Kocher's modification of the Billroth 1 operation, the ulcer recurred at the junction of stomach and duodenum six months after the operation. Of particular interest is Sokolov's series of 126 cases of peptic ulcer of the jejunum in which the complication occurred after 4.3 per cent of cases in which gastrectomy was performed, and in 11 cases in spite of the fact that no clamps were used in performing the suture.

Bruett examined the ulcer material of the Eppendorf Clinic to see whether it was true, as was formerly believed, that jejunal ulcer occurs just as frequently after the Billroth 2 operation as after gastroenterostomy. Among 500 ulcer operations performed in the last six years there were 400 resections by the Billroth 2 method (Reichel-Polya) and 12 by the Billroth 1 method. In the same period, 15 patients having jejunal ulcer were operated upon, nearly all of them according to the Billroth 2 method. In 14 cases a gastroenterostomy had been performed previously. A Billroth 2 operation had been done previously in only 1 case and in this instance was performed for a jejunal ulcer which developed after gastroenterostomy.

In the 12 cases in which the Billroth 1 operation was done there were 2 recurrences, one at the suture line and the other in the duodenum away from the suture line. Therefore the good results obtained at other clinics with the Billroth 1 operation were not confirmed. This was evidenced also by 2 recent recurrences of ulcer in cases in which a Billroth 1 operation was performed at another clinic.

The 53 cases of recurring ulcer following partial gastrectomy reviewed by Balfour are divided into three groups: (1) 28 cases in which the ulcer was found at operation; (2) 20 cases in which a clinical or roentgenological diagnosis (or both) of recurring ulcer was made, but in which, chiefly

because of mild symptoms, the patients did not come to operation, and (3) 5 cases in which the subsequent course was either positive or very suggestive of recurring ulceration. The second and third groups are not considered in this report. Of the 28 cases in which operation was performed, 14 followed resection for gastric ulcer, 8 were for persisting or reactivated duodenal ulcer following other operations, and 6 were for gastrojejunal ulceration. If these cases are classified according to operation, 3 followed resection of the Billroth 1 type, 6 followed resection of the Billroth 2 type, 10 followed sleeve resection, 7 followed a Polya operation of the posterior end-to-side type, and 2 followed resection completed as an anterior end-to-side gastrojejunostomy.

The Russian experience as given by Sokolov is particularly valuable inasmuch as the human material studied is essentially the same as that reported from other quarters where figures as high as 34 per cent were reported (Mount Sinai Clinic). Sokolov's experience gives the percentage of recurrence as from 1 to 2 per cent. Russian experience would indicate that it is impossible to perform a gastroenterostomy in such a way as to prevent the later development of this lesion. This is true also in the Russian cases of all methods of resecting the stomach with the exception of the Billroth 1 procedure. The nature of the suture and of the suture material, the use of clamps, etc., has no decisive influence upon the development of the peptic ulcer of the jejunum or gastrojejunal ulcer. In one-half of the Russian cases the symptoms of a peptic jejunal ulcer developed within a period of from one to two or three years after the primary gastroenterostomy, but in some instances there were painless periods of eleven, twelve and twenty-five years.

German (Bruett), English (Rowlands), American (Balfour), and Swedish (Nyström) experience seems to show conclusively that a peptic jejunal ulcer may occur even after extensive resection of the

stomach. Nystrom does not believe that these ulcers are "achylic," but he believes that the gastric chemistry still favors their formation. Up to the present time Nystrom has been able to collect from the literature 62 cases of peptic ulcer following resection of the stomach.

Wanke reported from the Kiel Clinic 70 cases treated by a Billroth 2 resection without a recurrence of the development of a jejunal ulcer. In more than 300 cases in which a Billroth 1 resection was performed from two to fifteen years ago there were two recurrences, and ulcer tumor in the anastomosis and a callous ulcer in the duodenum. In both of the cases with recurrence it is reported that the resection had not been extensive enough and the acidity was high. However, the recurrent ulcer and the jejunal ulcer were not the only evidences of failure in the ulcer treatment and not all of the lesions in the other cases were healed.

The subject of recurrent ulcer and gastrojejunal or jejunal ulcer can well be discussed together inasmuch as the basic causes operating in each are essentially the same. One exception should, however, be noted in recurrent ulcers in that this sometimes is an error and hides the missing of a previously existing lesion. This, however, does not prejudice the main issue. The preceding years have noted two main groups of observations: (1) A line of thought in which technique is said to be at fault. A change is however being noted in that no longer are minor factors in technique being implicated; the discussion concerns itself now with broad principles of operative technique and with major types of operations. (2) A line of thought in which other factors than those associated with operative technique are said to be at fault; this includes such two important subjects as the retention in the stomach of excessive amounts of acid and the retention in the stomach of foci of infection. Necessarily both of these topics are more or less intimately bound up with each other. The major part of our discussion will take

up the intragastric condition inasmuch as the types of operation necessary to correct these defects will first, be easily deducible therefrom and, second, the types of operation will be found to approximate themselves to one general group.

In recent years the presence of high acid contents in the stomach after operation has been associated in many men's minds with the appearance of secondary gastrojejunal ulcer.

Although ulcers may exist in the presence of a low gastric acidity, or absent in a high gastric acidity, it is assumed and proposed by an increasing number that the gastric acidity is the key to the "recurrence" problem; a properly reduced acidity means a cured patient. It is upon the question of acidity that the controversy mainly or entirely hinges. Those who, because of this belief favor the more radical procedure of resection have been charged with doing too great and an unjustified amount of surgery for the size of the lesion involved. This charge is possibly not a fair one since the gastric resection is not based upon the size of the lesion but upon the underlying chemical condition that is supposed to be responsible for the lesion.

This is the reason assumed at the Mount Sinai Clinic from which the exceptionally bad results reported by Lewisohn have come. And they carry this to the extent of believing, and the belief is based upon postoperative estimations of the gastric acidity, that when recurrences or gastrojejunal ulcers occur after resection the primary resection was insufficient in extent and they advise and do a further resection of the stump of the stomach.

The experimental work of Portis and Pertis shows that the gastric secretion in dogs after a subtotal gastrectomy shows an absence of free acid but a high combined acidity whereas the secretion from a Pawlow pouch, representing a similar part of the stomach, continues to secrete free acid after resection. They believe that the factor of neutralization plays the most important rôle in explaining the absence

of free acid observed experimentally and clinically in the gastric secretion after subtotal gastrectomy.

The artificial achylia produced may establish an entirely new and possibly harmful bacteria flora of the gastrointestinal tract, with consequent gastrointestinal abnormality.

At the Mayo Clinic (Balfour) the acid values of the gastric contents in cases of gastrojejunal ulcer as compared to the acid values before gastroenterostomy are usually, but not always of significance. In 40 per cent of their series of cases of gastrojejunal ulcer the free hydrochloric acid was either increased or very slightly reduced by the gastroenterostomy; but in 40 per cent, there was a marked reduction, and in 20 per cent, the free hydrochloric acid was reduced to zero. The fact that there was no free hydrochloric acid in one-fifth of the cases of gastrojejunal ulcer in which repeated and fractional examination of the gastric contents were made, possibly disproves the assumption of Lewisohn that achlorhydria following the primary operation affords protection against later ulceration.

Besides carrying the belief that this wiping out of the acid-making properties of the stomach is harmful, there are at least two reports (Ascoli-Konjetzny) which carry out this point of view. The past few years have seen a number of reports in which the association of the retention of relatively high values for the gastric acidity with the recurrence of ulcer or the appearance of gastrojejunal or jejunal ulcer is denied rather emphatically. This latter group associates the appearance of the secondary and gastrojejunal ulcers with the retention of foci of infection in the stomach wall.

The rôle of infection of the gastric wall and perigastric lymphatics in the development of recurrent gastrojejunal or jejunal ulcer is sponsored especially by Duval, Roux, Gautellier and Moutier and by Lecene. Duval, Roux, Gatellier and Moutier advanced this theory about three

years ago. Today this theory is generally accepted in France and is becoming more widely accepted in Germany. These men believe that gastrojejunal ulcers result from a localized inflammatory process due to extension of the infectious process from the ulcer site in the stomach. They suggest that the absence of renewed ulceration after extensive resection is due to the removal of the entire infected area rather than to the elimination of the acid-secreting portion of the stomach. They believe that the secondary ulcers are caused by including a part of the inflamed gastric wall in the general area of the new anastomosis and that the infection is not confined to the new opening but spreads along the efferent jejunal wall. They do not believe that unabsorbable suture material has much to do with the development of ulcer unless it is used in septic tissue, under which circumstances it may become a factor. The stomach clamp and the use of hemostats and other forceps applied to an inflamed tissue may cause ulcer as the result of induced ischemia and the intraparietal effusion of blood.

The evidence of this condition need not necessarily appear immediately even though it does sometimes in many of the cases; but it may appear somewhat later after an initial period of apparent health. The tendency in these quarters seems to be to connect the postoperative condition with foci of infection which the incomplete primary operation failed to remove. In the hands of Hertel, gastroscopy has revealed the presence of serious chronic catarrhal changes of the mucous membrane after gastroenterostomy and in the retained fundus after the radical removal of the antrum and pylorus.

The study of the specimens obtained in Nordmann's secondary operations showed that the pathological findings were slight when contrasted with the symptoms, and he assumes that symptoms were due to a gastritis, to distortion of the stomach and to spasm. Corroboration of this can be found in the single significant observation

made by Winkelbauer and Hogenauer; in all the dogs subjected to a gastrojejunal anastomosis for the purpose of studying the development of postoperative peptic ulcers there was marked hyperemia of the mucosa and submucosa of the distal loop of bowel. This was present as early as the first day after operation and as late as the fourteenth day. They regard this fact as indicating that ulcers never develop in the normal mucosa.

Konjetzny corroborates the beliefs of Duval, Nicolaysen and Hertel even though he believes that the findings of gastroscopy are not as conclusive as those of histological examination. He has never seen a typical ulcer without gastritis.

Clairmont and many of the continental surgeons are unwilling as yet to make definite conclusions with regard to gastritis following operations on the stomach because they still lack data based on a sufficient number of systematic investigations and histological studies. The problem seems complicated by the fact that in all surgical operations which cause deformities the changes produced are so extensive that their effect upon the stomach is not to be disregarded. Clinical observations alone are not sufficient as frequently different conditions produce the same external signs. The most contradictory views were expressed by Schindler who has come to the conclusion from gastroscopic findings, that gastritis is not a prerequisite for the development of ulcer. Schindler stated that he had never observed diffuse gastritis in cases of round ulcer, but had frequently noted it after gastroenterostomy.

I confess that the bulk of the reported evidences, my own experience and the observations that I have been able to make in the hospital, seem to bear this viewpoint out strongly. Duval draws the practical lesson from these observations and belief that no operation should be attempted during an acute phase of infection or before the abnormal biological reactions have disappeared. To prepare the patient for the operation is the most important thing. Bedrest, preoperative

vaccination, and operating in sound tissues improve the prognosis and prevent the subsequent appearances of secondary ulcerations.

According to Nordmann, the indications for a new operation in cases of patients previously operated upon for gastric ulcer depend upon the severity of the symptoms. As a rule, the most important symptom is intolerable pain, which is usually located in the mesogastrium, but often radiates to the back and occasionally also to the shoulder. Peptic ulcer of the jejunum can usually be suspected with considerable certainty. Roentgen-ray examination often leaves the diagnostician in doubt.

Secondary corrective operations are frequently postponed too long because of difficulty in determining the proper time for surgical interference. This difficulty is due to the fact that persons suffering from ulcer are usually of a nervous temperament.

Extensive resection is the best prophylactic treatment against recurrence of ulcer or the development of postoperative peptic ulcer. All of those in favor of the hyperacidity theory espouse this method of prophylactic treatment. However, in the opinion of those who believe in the "gastritis" theory, as defined by Duval, Nicolaysen and others the prophylactic action of extensive resections is due, not to suppression of the gastric zone which secretes hydrochloric acid, but to removal of the inflamed periulcerous zone. Nicolaysen believes that all operations for gastric ulcer should be preceded and followed by specific vaccination with streptococci or enterococci.

Rowland's discusses the following operative procedures:

1. *Simple Excision of the Ulcer.* If the ulcer is small and not encircling the stoma it is often possible to excise it and sew up the resulting wound in such a way as to enlarge the stoma or jejunal channel. In some cases, however, the ulceration may recur unless all of the causes of recurrences are eliminated.

2. *Excision of the Ulcer and Abolition of the Stoma.* If the ulcer is large or encircles the stoma, which is often contracted, it is necessary to excise the ulcerated area, thus detaching the jejunum from the stomach and, occasionally, to make a new and better stoma. If the pylorus and duodenum are healthy and patent it is not necessary to remake the gastrojejunostomy and it is much better to close the openings in the stomach and jejunum, thus re-establishing the normal anatomy and physiology of the parts.

3. *Abolition of the Stoma plus Gastro-duodenostomy.* If the original gastrojejunostomy was anterior it is possible to perform a gastroduodenostomy, using the opening on the anterior wall after excision of the ulcer.

4. *Partial Gastrectomy.* When the gastrojejunal ulcer is recurrent and complicated and when the duodenum is ulcerated, stenosed, or embedded in dense adhesions, it is wise to perform partial gastrectomy.

Allen's treatment of choice in marginal ulcer, when the primary operation was gastroenterostomy, is disconnection of the gastroenterostomy, resection of the ulcer and repair of the jejunum and stomach, provided that there is no stenosis in the pylorus, thus allowing the stomach to empty in its normal way. Allen does not think it justifiable as a primary procedure to sacrifice from one-half to two-thirds of the stomach for a duodenal ulcer when one cannot give the individual any assurance that the ulcer will not recur. Marginal or jejunal ulcers occur just as frequently after partial gastrectomy, and when they do recur a more formidable surgical procedure is presented than when a simple gastroenterostomy has been performed. An individual with a gastroenterostomy in whom a marginal ulcer develops has a much less hazardous condition than one in whom the primary operation was partial gastrectomy.

Cases of marginal ulcer in which the original lesion has healed call for restoration of the gastrointestinal tract to normal

and excision of the marginal ulcer. If the primary ulcer is still active, the treatment indicated is resection of half of the stomach and the ulcer-bearing area of the duodenum or resection of the jejunum, if the ulcer is located in that portion of the small intestine, followed by end-to-end jejunostomy.

Horsley states that the selection of the proper operation for peptic ulcer depends upon a careful study of the case and of the condition found when the abdomen is opened. Both Horsley and Woolsey believe that the best treatment is partial gastrectomy with removal of a considerable portion of the acid-secreting part of the stomach. There seems to be no reason for merely excising the ulcer and reestablishing the gastroenterostomy.

At the Mayo Clinic (Balfour) it is always assumed that a well placed anastomosis has brought about the healing of a duodenal ulcer. If such healing has taken place without producing any obstruction at the pylorus, and if examination of the duodenum and pyloric end of the stomach seems to show that it will maintain adequate drainage of the stomach, Balfour believes that the simplest and most rational procedures for the cure of the secondary ulceration is the disconnection of the anastomosis and the excision of the gastrojejunal ulcer. If such an operation be performed it is the procedure of choice; at the Mayo Clinic it has the great merit of being conservative. It is more often true, however, that although the original ulcer has healed, it has healed with such extensive scarring or so much deformity has resulted from previous operations on the pylorus, that the latter is incapable of carrying on its normal function and an operation as simple as the disconnection of the anastomosis is unwise and not possible. When this simple operation cannot be performed, the operation of election, from the standpoint of immediate and late results is the disconnection of the anastomosis with excision of the ulcer and partial gastrectomy.

Up to April, 1926, partial gastrectomy had been performed at the Mayo Clinic for uncomplicated gastrojejunal ulcer in 89 cases, with death in 3, a mortality rate of 3.37 per cent. This mortality rate is not excessive in view of the frequently formidable nature of the operation, the condition of the patient, and the excellent results which follow the operation. The most common and, unfortunately the most serious complication of gastrojejunal ulcer is the formation of a gastrojejunocolic fistula. Such a complication adds to the difficulty and risk of the operation. It is actually an unnecessary complication since there is always evidence of the ulcer long enough before the development of the fistula for the institution of adequate surgical treatment.

At the Mount Sinai Clinic (Berg) adherence to the principle of subtotal resection is held and all cases of secondary ulcer after previously performed primary operation of whatsoever kind are treated routinely in that fashion. The mortality is about 22 per cent. Their experiences with the palliative forms of operation

have not yielded such good results as are obtained in other clinics so that the minor forms of operation have been gradually and totally abandoned. This is a much more radical attitude than is ordinarily held; it is held on the same grounds as have impelled the men at Mount Sinai to practice routine subtotal resection of the stomach in the primary operation for gastric or duodenal ulcer; and, whatever one may say as regards the practices, beliefs and results obtained at other clinics, the radicalism seems to be necessary at that clinic because of the kind of patients and the character of the results which are obtained there.

The symptomatic results following partial gastrectomy for gastrojejunal ulcer fully justify adherence to the principle that this operation is necessary, certainly in cases which do not permit the conservative practice of disconnecting the anastomosis only and possibly as a routine measure. Complete relief of symptoms follows the operation in more than 85 per cent of the patients who recover from the operation.

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# THE DIAGNOSIS AND TREATMENT OF ACUTE CRANIOCEREBRAL INJURIES

## A COLLECTIVE REVIEW\*

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### PART II\*

#### TREATMENT OF ACUTE CRANIOCEREBRAL INJURIES

##### *Immediate Treatment*

Within the past decade the general trend has been toward conservatism in the treatment of acute craniocerebral injuries. Prior to this time, because of the relatively greater importance given to localized intracranial hemorrhage, operative procedures for the relief of intracranial tension were practiced rather frequently. At the present time it is realized that in by far the greater majority of cases increased intracranial tension is the result of edema which is dependent upon the cerebral trauma. The difference in treatment as practiced today from that practiced a decade ago is illustrated by the following figures: Sharp<sup>60</sup> (1916) operated upon about 30 per cent of his craniocerebral injuries; Wilensky<sup>71</sup> (1919), 24 per cent; Heuer<sup>72</sup> (1929), 23.7 per cent; Naffziger<sup>36</sup> (1923), 20 per cent; whereas Crawford and McClure<sup>3</sup> (1928) in their series of 441 cases operated upon only 4.3 per cent of the cases, and Fay<sup>11</sup> (1930) operated upon only 4.1 per cent of his cases. It is now generally accepted that in the majority of cases of craniocerebral injury, at least in those with no localizing signs, conservative treatment is not only less dangerous, but is more efficacious than operative treatment.

As many patients with acute craniocerebral injuries when first seen by the surgeon are in surgical shock, it is imperative that the shock be treated before the institution of any other therapy. The

patient should be immediately put in bed, external heat applied, and hot fluids administered. Fay<sup>11</sup> warns against the use of adrenalin or caffeine in the treatment of these cases, except in desperate cases as they frequently cause temporary improvement in the patient's condition and apparently later depress the circulatory and respiratory systems. He does employ pituitrin or strychnine, however. The administration of hypertonic glucose solution intravenously is justifiable, because not only is it of value in combating shock, but it is also of value in preventing and combating cerebral edema. Thomas<sup>73</sup> and Fay<sup>11</sup> recommend the administration of 50 per cent glucose solution in all cases of cerebral injury, even though cerebral edema is only suspected. They employ 50 to 100 c.c. of 50 per cent solution and believe that it is of distinct value in the treatment of shock. Fay<sup>11</sup> follows the administration of the hypertonic glucose solution with normal saline solution. Any external wound should be cared for as soon as possible, although undue manipulation is to be avoided until the patient recovers from shock. As soon as the patient's condition permits, an examination, especially a neurological examination, should be made, especial care being paid to the cranial nerves, pupillary reflexes, evidences of discharge of blood or spinal fluid from the ears, nose, or mouth, and evidences of paralysis or weakness. Even though these findings may not be abnormal, a record is extremely important in order to determine whether any deviation from normal subsequently occurs. Lumbar puncture should be performed as soon as the patient recovers from shock, both as a diagnostic

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and therapeutic procedure. A cerebrospinal fluid pressure higher than 10 mm. of mercury should be considered abnormal and enough fluid should be removed cautiously to decrease the pressure above 10 mm. of mercury by one-half; i.e., if the cerebrospinal fluid pressure is 20 mm. of mercury, enough fluid should be withdrawn to reduce the pressure to 15 mm. of mercury. Roentgenograms of the skull should be made as soon as the patient recovers from shock in order to determine the presence of a depressed fracture. As recommended by Weaver<sup>10</sup> and Davis,<sup>49</sup> in those cases in which there is discharge of blood or cerebrospinal fluid from the ears, no attempt should be made to irrigate the external auditory meatus, because of the danger of introducing organisms into the meninges. However, the external auditory meatus should be plugged with sterile cotton, possibly saturated with alcohol. Peet<sup>42</sup> believes that the external auditory canal should be mechanically cleansed of blood clots and wax, following which the entire canal is filled with 3½ per cent tincture of iodine. This is allowed to drain out and a sterile dressing applied to the ear. He warns against plugging the external auditory canal. In those cases in which there is a compound fracture or in which there is an injury to the scalp without injury to the underlying bone, active therapy is of utmost importance. As emphasized by Cushing<sup>43</sup> during the World War in compound fractures, especially those following gunshot injuries, the treatment consists of debridement, removal of the traumatized cranial tissue by means of a suction, following which the wound is tightly closed. Blahd,<sup>28</sup> Bower,<sup>44</sup> Connors,<sup>12</sup> and Weaver<sup>40</sup> advocate debridement in compound fractures and in scalp wounds. Weaver<sup>40</sup> is especially emphatic in emphasizing the necessity of debridement, because he considers wounds of the scalp as potential brain abscesses.

The frequently employed use of morphine and other narcotics in acute cranio-cerebral injuries is mentioned only to be

condemned. In acute cranio-cerebral injuries such drugs should never be used unless the patient is uncontrollable. Because of their depressing effects on the cerebrum, symptoms may be masked. Weaver<sup>10</sup> also believes that morphine should not be used for severe headache, because the drug depresses respiration. McClure and Crawford<sup>3</sup> state: "In the early stages we do not use morphine as a sedative or homatropine as mydriatic for fear of masking important signs." Bagley<sup>29</sup> prefers coal tar products and bromides in preference to morphine for the control of restlessness and delirium. According to Fay,<sup>11</sup> "Morphine or its derivative should never be given unless other sedatives fail, for there usually ensues respiratory difficulty due to intracranial pressure and edema with additional depressor effect of the narcotic." In the presence of restlessness, however, he advises the use of sodium luminal, chloral or bromide in order to secure relaxation so that the danger of hemorrhage is minimized.

#### *Repeated Lumbar Punctures*

As early as 1905 Quincke<sup>74</sup> emphasized the importance of the determination of the cerebrospinal fluid pressure and stated that the best results in the treatment of acute cranio-cerebral injuries was obtained by lumbar drainage. Rawling<sup>75</sup> was of the opinion, however, that in spite of the apparent advantage of lumbar drainage it is of little value in reducing intracranial pressure. More recently, however, due largely to the work of Jackson<sup>22</sup> and Munro<sup>63</sup> the advisability of lumbar puncture in the treatment of acute cranio-cerebral injuries has been especially stressed. In 1922, Jackson<sup>22</sup> reported 100 cases of acute cranial injury in which cerebrospinal fluid pressures were determined and which were treated by repeated lumbar punctures. He advocated performing lumbar punctures at intervals of six to twenty-four hours. Fay<sup>11</sup> believes that lumbar punctures should be performed as often as a rise in pulse pressure and respiratory



changes may indicate. Munro<sup>63</sup> treated 60 cases of acute cranio cerebral injury by lumbar puncture alone with only 7 deaths, a mortality of 12 per cent. Green,<sup>8</sup> Worster-Drought,<sup>76</sup> McCreery and Berry<sup>41</sup> believe that repeated spinal drainage is of more value than the use of hypertonic solutions in the severe cases. They have not hesitated to remove slowly enough fluid to lower the spinal fluid pressure to 10 mm. of mercury. In none of their cases did this require the removal of more than 50 cc. of fluid. Bagley<sup>29,77</sup> stresses the importance of not performing spinal drainage in those cases in which pure blood is present within the subarachnoid space. He believes that in this type of case it is better to wait until the blood becomes mixed with the cerebrospinal fluid before attempting spinal drainage as the prognosis in the former case is extremely grave. Holbrook,<sup>9</sup> McClure and Crawford<sup>3</sup> are less radical, remove smaller amounts of fluid, and do not decrease the cerebrospinal fluid pressure to such a degree.

Repeated lumbar punctures are of value in acute cranio cerebral injuries, not only because the cerebrospinal fluid pressure is decreased, but also because of the removal of any blood which may be present in the subarachnoid space. As mentioned before, blood produces a sterile meningitis and is frequently responsible for late sequelae. Fay<sup>11</sup> believes that repeated lumbar punctures are necessary for a period of ten days, when blood is present in the spinal fluid, because it will take this length of time before all the red blood cells are hemolyzed. He also is of the opinion that spinal drainage is less necessary in those cases in which the spinal fluid contains no blood. Repeated spinal punctures in the treatment of acute cranio cerebral injuries have been used successfully by the following authors: Trotter,<sup>4</sup> Heuer,<sup>72</sup> Thorning,<sup>45</sup> Fay,<sup>11</sup> Demmer,<sup>78</sup> Symonds,<sup>27</sup> Gage,<sup>62</sup> and the author.

#### *Hypertonic Solutions*

In 1919 Weed and McKibben<sup>79</sup> demon-

strated that cerebrospinal fluid pressure and brain bulk could be influenced by the intravenous injections of hypotonic and hypertonic solutions. They showed that cerebrospinal fluid pressure experimentally could be markedly decreased by the intravenous injection of hypertonic solutions. Haden<sup>80</sup> was the first to apply this principle clinically. He employed hypertonic glucose solution intravenously in a case of cerebrospinal meningitis with good results. Cushing and Foley<sup>81</sup> demonstrated that cerebrospinal fluid pressure could be decreased by the ingestion of hypertonic solutions. Sachs and Belcher<sup>82</sup> were able to relieve a patient with a brain tumor and with increased intracranial pressure by the intravenous injection of hypertonic sodium chloride solution. Foley and Putnam,<sup>83</sup> in 1920, showed that the introduction of hypertonic solution into the intestinal tract would produce similar but less marked results. Sachs and Malone,<sup>84</sup> working experimentally, were able to decrease the brain volume in a dog following the intravenous injection of a 30 per cent chloride solution. Within ten minutes after the administration of the solution a change was noted, and a maximum was reached in forty-five to sixty minutes. They found that the rate of injection could exceed 1 c.c. per minute, otherwise there would be a fall in blood pressure and respiratory disturbance. Peet<sup>42,85</sup> believes that the intravenous administration of hypertonic sodium chloride solutions causes toxicity and prefers the use of hypertonic glucose solution. Dowman<sup>86</sup> recommended the intravenous injection of hypertonic solutions in increased intracranial pressure and also advised the repeated administrations of magnesium sulphate by mouth. Ebaugh and Stevenson<sup>87</sup> showed that the intracranial tension could be better controlled by the intravenous injection of hypertonic glucose solutions than hypertonic Ringer's solution. The decrease in intracranial pressure was more gradual following the use of glucose, but no subsequent rise was noticed even after eight hours and forty-

five minutes. Following the use of hypertonic Ringer's solution, however, the maximum fall in cerebrospinal fluid pressure was attained in one and three-quarter hours, the pressure returning to normal in three and a half hours. Foley<sup>88</sup> showed that following the intravenous injection of a hypertonic sodium chloride solution that not only was the cerebrospinal fluid pressure diminished, but also that there was a decrease in the brain and cerebrospinal fluid volume. Fay,<sup>89</sup> in 1923, advocated the use of magnesium sulphate by rectum and states that the effect becomes pronounced within an hour. He employs  $1\frac{1}{2}$  oz. of magnesium sulphate in 8 oz. of water. He believes that this is better than the administration of sodium chloride by mouth in that it causes no vomiting and no distress. He also states that sodium chloride is dialyzable and an increased chloride content of the blood leads to secondary tissue retention with a rapid return of symptoms after its administration. Magnesium sulphate, however, is non-dialyzable and produces a rapid dehydration of the blood plasma by excretion of fluid into the intestinal wall. Fay<sup>90</sup> was able to demonstrate experimentally that magnesium sulphate is about twice as efficient as a dehydrating agent in the intestine as is sodium chloride. He<sup>11,91</sup> emphasizes the importance of restricting fluids during the dehydration therapy, but warns against its use in shock and against "over dehydration." Dowman,<sup>86</sup> in 1922, recommended the use of magnesium sulphate both by mouth and by rectum in cases of increased intracranial pressure. Since this time it has been used extensively by many authors, especially the rectal administration which has the advantage that the patient is little disturbed, its effect is prompt, and there is no danger. Connors,<sup>12</sup> on the other hand, is of the opinion that the administration of magnesium sulphate by mouth is of relatively little value and states that he has discontinued its use. Howe,<sup>92</sup> employing a large number of salts: viz., sodium bicarbonate, sodium sulphate, sodium chloride, calcium

lactate, calcium chloride, sodium citrate, sodium tartrate, and dextrose, found that sodium bromide, calcium lactate, calcium chloride, and magnesium sulphate were too toxic to be used intravenously. Sodium citrate, sodium tartrate, sodium bicarbonate were relatively ineffectual, whereas sodium sulphate, sodium chloride, concentrated Ringer's and Locke's, tyrode and dextrose solutions produced satisfactory decompression. Sodium sulphate was not toxic at first, but later caused death. Sodium chloride produced secondary edema, which objection also applies to Ringer's, Locke's, and Tyrode's solutions, although they were less toxic than sodium chloride. Howe<sup>92</sup> found that dextrose was the only one of the group that was non-toxic and produced a satisfactory decrease in the cerebrospinal fluid pressure. Henschen<sup>21</sup> advocates the administration of magnesium sulphate either by mouth or per rectum, as well as the intravenous injection of hypertonic saline or glucose solution. Morrissey,<sup>93</sup> on the other hand, believes that relatively little decrease in pressure can be accomplished by the use of magnesium sulphate, but believes that hypertonic salt solution given intravenously has a definite action in reducing intracranial pressure. Glucose in a 50 per cent solution is the best dehydrating agent which can be employed intravenously. Its action although slightly less prompt than that of hypertonic sodium chloride solution, is, however, more lasting, (according to Fay,<sup>11</sup> from one to four hours). Its intravenous use is also much safer than that of the hypertonic sodium chloride solutions. From 50 to 100 c.c. of a 50 per cent glucose solution may be administered intravenously from every six to eight hours, depending upon the severity of the cerebral edema. Thomas<sup>73</sup> recommends the administration of from 100 c.c. to 300 c.c. of 50 per cent glucose in a day. In contrast to the hypertension of the cerebrospinal fluid which is usually associated with cerebral injuries, rarely a hypotension may occur. This phenomenon was first emphasized by

Leriche<sup>94</sup> in 1920. In the 414 instances in which lumbar puncture was done in McCreery and Berry's<sup>41</sup> series, a hypotension of the cerebrospinal fluid was found in 12 cases. Leriche<sup>94</sup> advocated the use of hypotonic solutions and even sterile water intravenously in the treatment of patients with a decreased cerebrospinal fluid pressure. Excellent results in these cases have been obtained with this therapy by Henschel,<sup>21</sup> Mallet-Guy and Etienne-Martin.<sup>95</sup> The latter authors believe that in contrast to hypertensive disturbances, which produce symptoms for a relatively short period of time, the hypotensive disturbances cause prolonged complications and distressing sequelae. Persisting headaches (usually in the occipital region), asthenia, and a state of nervous irritability are frequently present.

### *Operative Treatment*

Even though at the present time the treatment of acute craniocerebral injuries consists largely of conservatism, there are certain definite cases in which operation is indicated. Operation is indicated in those cases with scalp wounds, compound or depressed skull fractures, and localized intracranial hematomata. According to Fay:<sup>11</sup>

Operation is indicated under only two conditions: (a) a compound fracture of the skull (with or without comminution), where simple cleansing of the wound is required, (b) extradural or subdural hemorrhage (middle meningeal or venous), where progressive focal signs are present. Rarely, if ever, does a depressed fracture require elevation during the early days following injury unless this depressed fracture produces local or dangerous pressure symptoms.

Peet<sup>42</sup> is of the opinion whenever a diagnosis of fracture of the cribriform plate can be made, as indicated by a discharge of spinal fluid from the nose, that an operative procedure is indicated. Patients with extradural hemorrhage or even intradural localized hematomata with focal symptoms and signs should be operated upon in

order to evacuate the blood clot and also to secure hemostasis. Most authors believe that contusion of the brain as such should not be operated upon, however, Arnaud and Albert Crémieux<sup>16</sup> are of the opinion that localized ecchymosis of the cerebral cortex, surrounded by an area of edema, should be given the advantage of a decompressive operation. Bagley<sup>29</sup> is emphatic in stating that operative procedures should not be performed in cases with hemorrhage unless a clot has formed. If a clot has not formed, the operation will favor further bleeding. In those cases in which it is impossible to control the increased intracranial pressure by spinal tap and the intravenous use of hypertonic solutions, decompression may be indicated in order to relieve the increased cerebral pressure. Bower<sup>41</sup> believes that, if after the second aspiration of spinal fluid, there is an increase in the cerebrospinal fluid pressure of 20 mm. of mercury and no improvement has occurred, operation is indicated.

### *Prognosis*

Prognosis in acute craniocerebral injuries varies considerably and is dependent upon the extent of the injury and the type of therapy instituted. When considering prognosis, it is essential to differentiate between prognosis as to life and prognosis as to complete restoration of function. Munro<sup>63</sup> collected 2908 cases from the literature in which there was a mortality of 37.8 per cent. He reports a mortality of 19.6 per cent in the Boston City Hospital series. The mortality rates as reported by various authors are as follows: Jackson,<sup>22</sup> 25 per cent; Thorning,<sup>45</sup> 23 per cent; Bland,<sup>28</sup> 33 per cent; McCreery and Berry,<sup>41</sup> 39 per cent; McClure and Crawford,<sup>3</sup> 14.7 per cent; and Fay,<sup>11</sup> 20.8 per cent. In Fay's<sup>11</sup> series of 48 cases the mortality rate of those patients who survived the sixth hour after admission was 10.4 per cent. Fay<sup>11</sup> believes that the reduction in the mortality rate in those cases which survive the six-hour period is due to improvement in treatment of these cases,

especially the introduction of the more conservative measures.

Undesirable effects and sequelae frequently follow cerebral injury and may produce very definite disability. English<sup>96</sup> states that there is an element of truth in the statement, "A man is never the same after a head injury." From his experience he believes that there is some degree of mental impairment in about 10 per cent of patients. He feels that all individuals with cranial injuries should be given the advantage of a prolonged mental rest after the injury. This period of rest he believes should be twice as long for intellectual workers as for manual workers. Fay<sup>31</sup> has found that patients who have a relatively mild head injury frequently develop, after their immediate recovery, intermittent headaches, irritability, loss of memory, and ambition. He believes that the ultimate recovery of a patient often depends upon the treatment instituted during the first seventy-two hours. Employing encephalography he<sup>34</sup> has been able to demonstrate a marked cerebral atrophy, even the absence of neurological signs in many of these patients. The degree of cerebral atrophy is often out of proportion to the severity and the location of the lesion. The areas of cerebral atrophy are usually found in the frontal and parietal portions of the brain, whereas the temporal and occipital regions are not involved. This atrophy, according to Fay,<sup>34</sup> is the result of an abnormal stagnation of cerebrospinal fluid in the subarachnoid space, caused by the "blocking" of the Pacchionian bodies with blood present in the cerebrospinal fluid. Gerhartz<sup>97</sup> has seen cases in which there was prolonged increase in cerebrospinal fluid pressure, which he believes is due to a chronic traumatic meningitis and is also a result of blood in the subarachnoid space. Hoag<sup>98</sup> states that following head injuries about 80 per cent of patients have a continuation of symptoms. Eight per cent of his patients showed decidedly psychotic symptoms; only 10 per cent showed no subjective complaints. The most prominent

symptoms in his series were headache and vertigo, which continued occasionally for a long period of time. Less common complaints were tremor, insomnia, nausea, cardiac palpitation, and inability to concentrate or use the memory, or to stand the stress of exertion. Sharp<sup>99</sup> stated that in 68 per cent of a group of head injuries which he was able to follow had sequelae, consisting of headache, change in personality, depressed or excitable conditions, and exceptionally convulsive seizures. More than 50 per cent of these patients had increased intracranial pressure. At operation Sharp<sup>99</sup> found no gross lesion, but a whitish connective tissue residue could be seen along the supracortical veins and sulci, which he believes produced a partial blocking of the absorption of the cerebrospinal fluid. Of McClure and Crawford's<sup>3</sup> patients, 64.2 per cent were discharged as apparently cured and did not return; 17.7 per cent were discharged with unfavorable symptoms, and 3.4 per cent were either transferred or left against advice. In an attempt to follow up those patients who had disappeared from observation, questionnaires were sent to 229. Only 76 (33.2 per cent) replied. Of this number, 71.1 per cent suffered or were still suffering from one or more unpleasant sequelae. These sequelae in order of their frequency were: vertigo, headache, fatigability, nervousness, irritability, impairment of memory, mental changes, paralyses, and convulsions. From the analysis of their series, McClure and Crawford<sup>3</sup> consider the prognosis best in children, as there were fewer sequelae and a greater percentage of recoveries. Children, however, are more apt to develop such sequelae as epilepsy and mental retardation. McClure and Crawford<sup>3</sup> emphasize the importance of guarding the prognosis until at least six months or a year have passed. Kasanin<sup>100</sup> emphasizes the importance of personality changes in children following trauma. In addition to personality changes there may be headache, giddiness, tinnitus, and memory defects. Of 80 patients with cerebral contusion

reported by Symonds,<sup>27</sup> 22 per cent made a complete recovery, 46.5 per cent were able to return to light work, and 10 per cent were totally incapacitated. Worster-Drought<sup>76</sup> believes that the percentage of complete recoveries following major cerebral contusion is less than 22 per cent. He has seen epilepsy occur three to four years after the accident and states that it may occur much later. He believes that head injuries of the left frontal region are the most serious as regards prognosis with respect to mental changes. Trotter<sup>4</sup> frequently found such symptoms as headache, dizziness, mental change, occurring after head injuries, which were due to a persistent elevation in increased intracranial pressure. Ritter and Ströbel<sup>23</sup> found that of their patients, 38.7 per cent with cerebral concussion and 44.7 per cent with concussion of the medulla oblongata were able to resume full work.

In an attempt to relieve the post-traumatic headache and dizziness, Penfield,<sup>101</sup> Gardner,<sup>102</sup> and Kaskanin<sup>100</sup> advocate the lumbar insufflation of air. Penfield<sup>101</sup> reports 7 patients having post-traumatic headache and dizziness, all of whom were relieved of their headaches. Six complained of vertigo, which was also relieved. Gardner,<sup>102</sup> in examining encephalograms in a series of 33 cases of so-called idiopathic epilepsy and post-traumatic sequelae, found the following common abnormalities: (1) dilatation of a portion of the subarachnoid space with apparently resulting brain atrophy; (2) dilatation or distortion of a portion of all the ventricular system, and (3) an obstruction of a portion of a subarachnoid space which is probably the result of abnormal pia arachnoid adhesions. In an analysis of 19 patients in whom sequelae followed cranial trauma and in whom a clinical diagnosis of idiopathic epilepsy was made, Gardner<sup>102</sup> found the following results following the therapeutic insufflation of air. Of 19 patients with post-traumatic epilepsy there was an average "follow-up" of nine months in 12; 4 of these had no further

attacks, 5 were apparently improved in that the attacks were less frequent, in 1 the attacks were unchanged, and in 2 the attacks were more frequent after encephalography. In 12 patients suffering from headaches, 2 were greatly improved, 8 were improved, 1 showed no improvement, and 1 was worse. In 6 suffering from tinnitus, 2 were entirely cured, 2 improved, 1 showed no change, and 1 was worse. Of 8 patients with vertigo, 2 were entirely relieved, 3 improved, and 3 showed no change.

#### SUMMARY

Injuries to the cerebrum are of paramount importance in trauma to the head. Unfortunately, in the past too much attention has been paid to injury to the cranial vault rather than to injury to the cerebrum itself.

Craniocerebral injuries should be classified into two main groups: (1) those with cerebral injury which may be associated with or without cranial injury, and (2) those without brain involvement. In the first group are concussion, edema, contusion, laceration, and hemorrhage. In the latter group are scalp wounds and the various types of skull fractures. Concussion of the brain is a justifiable diagnosis as a clinical entity if it is kept in mind that concussion is a physiologic and not a pathologic lesion. It is characterized by immediate unconsciousness, associated with headache, vomiting, and occasionally circulatory and respiratory disturbances. Characteristically, the clinical course is such that the patient recovers completely within from twenty-four to forty-eight hours.

Edema of the brain is the most important pathologic lesion as it is the most frequently encountered. The extent of edema varies considerably. Edema is the most frequent cause of increased intracranial pressure. Not infrequently a vicious circle is produced; i.e., as a result of the edema there is interference with the venous return, which causes a diminished absorption of the cerebrospinal fluid, which in

turn produces an increased intracranial pressure. Contusion and laceration are found in the more extensive injuries of the cerebrum and vary largely in degree. Lacerations are usually associated with lesions of the cranium, whereas contusions frequently are not.

Hemorrhage is of two types, intradural and extradural. Associated with every cerebral injury, from the slightest contusion to the extensive laceration, there are varying degrees of hemorrhage. Intradural hemorrhage is a result of injury to the brain substance, whereas extradural hemorrhage occurs as a result of injury to the middle meningeal artery or rarely to the lateral venous sinus. Subdural hemorrhage is of importance because of sequelae which may develop, such as sterile meningitis, abnormal accumulation of cerebrospinal fluid, which may subsequently lead to cerebral atrophy, and localized cystic changes occurring in hematomas. Extradural hemorrhages occur relatively infrequently, but are of surgical importance as they are amenable to surgical intervention. Scalp wounds are of great importance, because they represent potential brain abscesses, as organisms may gain entrance to the meninges.

Fractures of the skull are divided into two main types, those of the vault and those of the base. In the autopsy series fractures of the base occur much more frequently than fractures of the vault, whereas in the clinical series fractures of the vault are recognized more frequently. This discrepancy is probably due to the fact that fractures of the vault are more readily recognized roentgenologically than are fractures of the base. Simple and comminuted fractures of the vault are of no significance clinically. Depressed fractures of the vault are of significance, because of the cerebral injury which may be associated with it. Fractures of the base are of great significance, because almost invariably they are compound fractures in that fracture extends into the nose, nasal accessory sinuses, mastoid process, or

middle ear. Compound fractures of the vault are of importance because of the danger of infection.

As regards diagnosis the history, especially the history of unconsciousness, is of extreme importance. Pulse and respiratory rates are of little value in diagnosing cerebral injury early in the condition. They are of prognostic value. Careful examination of the entire body, especially that of the nervous system, is of great importance. Pupillary changes are of relatively little diagnostic value, but are of great prognostic value. When these changes are unilateral, they may be of localizing value. Examination of the eyegrounds is of little importance as far as an indication of increased intracranial pressure is concerned. Blood pressure determinations are of little value except in shock, as whenever hypertension is obtained, it is indicative of an advanced lesion.

Of greatest importance as regards the diagnosis of acute craniocerebral injuries is spinal tap with manometric determination of the cerebrospinal fluid pressure. It is the earliest and most reliable method of determining increased intracranial pressure. The finding of blood in the cerebrospinal fluid is of utmost importance, because of the subsequent sequelae which may develop because of the blood in the subarachnoid space.

The treatment of acute craniocerebral injuries is one of conservatism. Non-operative treatment is indicated unless there are very definite indications for operative interference. As most patients with acute craniocerebral injury are in shock, it is imperative to treat the shock first. This is best done by the administration of hypertonic (50 per cent) glucose solution intravenously. As soon as the patient has recovered from shock, every effort must be made to prevent and combat the development of cerebral edema. This is best accomplished by the use of hypertonic solutions by mouth, by rectum, or intravenously. Magnesium sulphate is admin-



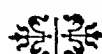
istered either by mouth or by rectum after the patient has recovered from shock, and 50 per cent glucose solution is used intravenously. Repeated spinal tap with drainage of the cerebrospinal fluid is indicated in cases of cerebral hypertension. Operative procedures are indicated in scalp

wounds and compound fractures, which require debridement and primary suture. Depressed fractures should be elevated. A small percentage of those patients who do not respond to the conservative treatment should be given the advantage of an operative decompression.

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\*For References 1-70 see May issue, p. 240.



# AN UNCOMMON CONGENITAL MALFORMATION

## WITH CASE REPORT\*

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**B**ABY girl: born the morning of November 27, 1929, precipitate labor before mother's arrival at hospital.



FIG. 1.

Baby to all appearances normal. Nurse reported passage of meconium during first twenty-four hours. Nursed well. On the third day abdomen was moderately distended and an enema was given without result. On the third day milk of magnesia and high enemas were administered without results. Fourth day 8 c.c. of castor oil. No vomiting. Baby nursed well. On the eve of seventh day it vomited; vomitus had strong odor but not fecal; during night vomitus undoubtedly fecal. An attempt at proctoscopic examination unsatisfactory, except to determine patency of anus. At noon, December 5, an exploratory

laparotomy was made. Preoperation diagnosis: Intestinal obstruction, in a girl baby nine days old, with history of normal bowel movement during first twenty-four hours, with no subsequent movements. For past twelve hours patient has had two or three vomiting spells, vomiting apparently feces.

Under ether a midline incision above umbilicus was made and the rectum, sigmoid, and entire colon and greater part of ileum were found to be very small and cord-like. The contents had the feel of putty. The jejunum was considerably distended. The intestine from the jejunum was examined down to the cecum, and its diameter estimated at 10 mm. and the colon from cecum to lower rectum had a diameter of 5 mm. The condition being inoperable, wound closed, and patient died December 7, 1929.

The accompanying photograph by the Signal Corps, United States Army, Hawaiian Department, shows the normal slightly distended jejunum and the ileum and colon for comparison. The hole in the ileum near cecum was made at autopsy. The entire intestinal tract was patulous.

### ABDOMEN

#### *Autopsy record follows:*

"On opening abdomen no free fluid or adhesions found. All organs are in normal position.

### GASTROINTESTINAL TRACT

"The stomach and duodenum are about normal size. The upper jejunum is somewhat distended and bluish red in color. The ileum and entire colon are pale in color and small. The ascending, transverse and descending colon measure 16 in. in length. The sigmoid colon and descending colon are small, being between 5 and 6 mm. in diameter. On opening, canal is patent, will admit a very small probe, and contains a small amount of grayish, sticky mucoid-like material. The cecum is slightly

\* Submitted for publication November 23, 1930.



larger than the descending colon, contains more material similar to sigmoid and measures 9 mm. in diameter. The ileum is about 8 mm. in diameter. Thirty-two inches above ileocecal valve the intestines are somewhat constricted, being about the size of sigmoid, then there are 6 in. that approach normal size; and again there is a constriction. The upper jejunum measures 3 cm. in diameter and contains normal appearing thin, yellowish feces. Other organs not removed. Those in abdomen appear normal.

#### ANATOMICAL FINDINGS

1. Malformation, congenital, colon and ileum (narrowing).
2. Intestinal obstruction, due to 1.

#### MICROSCOPICAL SECTIONS

"Microscopical sections from sigmoid colon, ascending colon and ileum show mucosa present and apparently normal. Two muscle coats present, which also appear normal, but on stretching to the size of normal gut the muscle and mucosa are extremely thin, and evidently lack power"—H. R. Livesay, Major, Medical Corps.

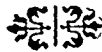
The reason for reporting this case is first, its rarity. Mummery, in "Diseases of Rectum and Colon," states:

Congenital abnormalities of the colon itself are very rare and as a rule, when found are associated with congenital abnormalities of other parts. The colon or some part of it may be completely absent or represented by only a fibrous cord. Some form of atresia is the most common. Atkins described a case where the whole colon and rectum were rudimentary and about the thickness of an ordinary quill, there being, however, a small lumen throughout the entire colon—his case was associated with imperforated anus.

Second, the deceptive history of obstruction as manifested by normal meconium bowel movements during first twenty-four hours, which can now be explained by the fact that this was not an obstruction due to an atresia, but an obstruction due to hard inspissated milk curds, in the normal lumen with musculature and mucosae so undeveloped that the inspissated curds could not be forced along the narrowed canal, thus obstructing further passage of meconium.

In the original picture the lumps of curd can be distinctly seen through the bowel wall.

I am indebted to Major Norman McL. Scott for the history of this case.



# CHRONIC CONSTIPATION

## RATIONAL EXPLANATION OF THE SYMPTOMATOLOGY, WITH SUGGESTIONS FOR TREATMENT\*

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THE object of this paper is an analysis of the symptomatology and the mechanism by which the symptoms are produced in chronic constipation and chronic colitis. This necessitates a more or less general discussion of this disease.

Alvarez and others have shown the small intestine has three types of movements.

1. Rhythmic movements due to contractions of the circular muscles. These occur more rapidly near the pylorus and diminish in frequency the nearer they approach to the ileocecal valve.

2. Pendulum movements due to contractions of the longitudinal muscles.

3. Rush movements due to contractions of both longitudinal and circular muscles.

The first two serve to mix the intestinal contents while the third carries the mixture toward the cecum.

It has been shown that the colon also has rhythmic movements but they occur much less slowly than in the small intestine. In addition from time to time mass movements occur. These will push a bolus of stool from the hepatic flexure clear into the rectum at which time a desire to defecate is produced.

Constipation is an insidious trouble seldom descending upon the individual with sufficient suddenness to permit one to set a definite time of onset. In all probability improper evacuation has been present a long time before sensations rise to the patient's consciousness, resulting in symptoms.

Anything that interferes with rhythmic or mass movements of the large intestine or with the sensitiveness of the anal canal will serve to delay evacuation. Hence we must look to the nervous system for the onset of constipation. Almost all have had

the experience of passing from a state of normal evacuations to one of acute constipation with no change in their lives other than the excitement of a train ride. Todd has shown a diminution of rhythmic movements of the colon in students during an examination. It is reasonable that excitement or nervous tension would produce a contraction of all the alimentary sphincters except the cardia inasmuch as they are supplied by the sympathetic nervous system. Thus undue excitement by causing a contraction of the rectal sphincters could keep the bowels from moving regardless of the entrance of stool into the rectum causing the desire to defecate.

Reasoning from this, one can appreciate how the increased nervous tension of our present civilization can cause a slight delay in the beginning to be followed after a few months or years by chronic diminution of rhythmic contractions and mass movements of the colon with a state of continuous increased contraction of the rectal sphincters, thus causing the stool to be retained in the colon from twenty-four to forty-eight hours longer than it should remain.

This delay and undue contraction of the sphincters could well produce dilatation of the hemorrhoidal veins with irritated pockets about the rectum. Nor would it take a great flight of the imagination to conceive a colitis or at least an irritable mucous membrane resulting from the retention of stool for so many hours after it should have been deposited in the toilet.

Alvarez has pointed out a law that stimulation at any point tends to hold back material coming down from above. One can readily see then that because of the irritability of the rectum and colon

\* Read before the Los Angeles Surgical Society, January 10, 1930.

there would not only be a delay in this region but it would extend to a greater or less degree clear to the cardia. Again, adhesive bands, congenital or acquired, may act as irritating points delaying peristalsis thus causing stool retention and resulting mucous membrane pathology. Malformations of the colon may cause the same results. It is at this period that symptoms have become so manifest a physician's advice is sought.

There are three groups of symptoms produced by these conditions:

1. Those due to reversed peristalsis.
2. Those due to intestinal distention.
3. Those due to toxemia.

It has been shown that if a small portion of the small intestine is injured, reverse ripples will ascend from this area extending even to the cardia. Is it not reasonable then to believe that as a result of colon irritability reverse ripples ascend the small intestine and if marked enough may ascend clear to the cardia, even causing a relaxation of this sphincter thereby letting gastric juice into the esophagus thus producing water-brash and heartburn? The sensation of heaviness and weight in the epigastrium, loss of appetite, and furred tongue can all be explained on this basis. Lycopodium deposited in the rectum at night has been found on the tongue in the morning, having been carried up by reverse ripples during the night. Possibly some of the material found on a coated tongue in the morning has been carried up in the same manner by reverse ripples due to colon irritability. A bad breath and a bad taste could be produced in the same manner.

The feeling of fullness after eating even a small meal, belching, sour stomach, and the gnawing sensation simulating peptic ulcer might well be due to these groups of reverse ripples.

Donaldson working with a group of students upon whom acute constipation was produced found that the symptoms of languor, heaviness in the epigastrium and headache were relieved immediately

following a bowel evacuation by an enema to recur immediately following distention of the rectum with cotton. These symptoms which are so common in constipation appear, then, due to rectum and colon distention. Also in this disease flatulency is extremely frequent. If a flatulent patient is observed with a fluorescent screen the gas will be found almost entirely limited to the small intestine. Beyond a reasonable doubt there is no excessive production of gases but an improper absorption of the gases formed in the normal process of intestinal digestion. If good drainage from the colon is established by soothing means, in other words if colon irritability is relieved, flatulence disappears.

The normal mucous membrane of the intestine is so resistant that bacteria and the various toxins present cannot permeate it. However, if this membrane becomes irritated or inflamed the resistance is so lowered that both these substances can pass through into the circulation. It is reasonable to believe that fecal pools due to adhesions or malformations can readily lower the resistance, if not produce actual inflammation of the mucous membrane. It is also reasonable to believe that the mucous membrane of the colon may become irritated if general stasis is present over a long period of time. If in this sort of state the bacterial flora becomes pernicious also, one can readily imagine that substances can enter the circulation producing a long train of symptoms resulting from this chronic toxemia.

In concluding this paper I should like to discuss briefly a rational treatment based upon the foregoing premises.

If irritation and inflammation of a portion of the intestine cause an inhibition of the downward waves and send reverse waves upward then the cure is to remove the points of irritability. Hemorrhoids, rectal pockets, hypertrophied and inflamed Houston's valves as well as contracted rectal sphincters are not only common but some of these are almost universal in any patient suffering from

chronic constipations. Hence the treatment should be begun by removing these factors by surgery or other means.

When this is done relief of the irritated or inflamed mucous membrane should next be sought. This can be accomplished by obtaining proper drainage and by applying soothing applications directly to the mucous membrane.

The two great factors in diets most efficient in this trouble are based on colon distention and upon the principle of poulticing. Diets rich in vegetable roughage, bran, agar and psyllium seed not only produce distention thus stimulating peristalsis, but by producing a bland soft succulent mass act as a poultice to an irritated surface thus relieving the inflammation and irritation.

Instead of bran acting as an irritant and thus stimulating peristalsis, I believe it acts as a soothing mass retaining water and forming bulk. The same thing occurs with the cellulose of vegetable roughage—water is retained and a succulent soothing mass is produced. Agar and psyllium seed are probably the best water carriers and by their bland mushy bulk not only poultice the intestine but stimulate peristalsis. Petroleum oil acts by its lubricating qualities to produce a soothing slippery mass thus hastening evacuation.

It is of extreme importance to continue

the use of these substances long after good evacuations are obtained as it takes many months longer to relieve the irritated and inflamed mucous membrane than it does to secure proper drainage and if the irritability of the whole colon is not relieved it is but a question of time until there is a recurrence of symptoms.

Fruits probably act by stimulating intestinal secretions and by changing bacterial flora through their sugar content.

It is also important to obtain nervous relaxation as this in turn relieves sphincter spasm. Colon irrigations, hot applications or any other measures which tend to sedation are helpful for relief of this trouble.

To summarize, then, we have, first, a law indicating that any point of inflammation or irritation in the alimentary canal blocks the waves coming down from above and tends to produce reverse peristalsis.

Second, we believe constipation is due to some area of irritation or inflammation somewhere below the ileocecal valve. This may be a spastic rectal sphincter, rectal inflammation, colitis or adhesions.

Third, the symptoms accompanying chronic constipation are due to reverse peristaltic waves, to intestinal distention or to toxemias.

Fourth, the cure of this trouble then, is the removal of these points of irritation or inflammation.



# CARCINOMA OF THE PROSTATE:

## UNUSUAL METASTASES\*

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THIS paper might well have as its text Dr. Osler's well-known dictum, "The difference between a good doctor and a poor doctor is that a good doctor knows how to make a rectal examination." Cancer of the prostate is not as infrequent as has been usually supposed, it being present in over 20 per cent of the cases of urinary obstruction. It is generally accepted that one-third of all cases of cancer of the prostate show bony metastasis when they first consult a doctor, a fair percentage have involvement of pelvic and abdominal lymph glands (not as a rule demonstrable), and a small percentage have vesical metastasis. Hence, at least 50 per cent are beyond the possibility of a cure before the diagnosis is made. We may have well established carcinoma from metastasis in almost any part of the body without the prostate being suspected as the primary site because of the absence of definite urinary symptoms. In many instances extensive involvement of the seminal vesicles and metastases in the bones occur without glandular involvement. The osseous system is eventually invaded in almost every case.

In some cases the bony metastases alone produce symptoms. Many a patient is treated for an osteoarthritis for months before his urinary symptoms develop sufficiently to attract the physician's attention. A residual of urine is then found, along with a cancerous prostate that has already extended to the bones and the lungs. Even then the patient may live for several years with no other treatment than deep therapy. Howard E. Ruggles has had several patients under observation for eleven years.

If a rectal examination was made an integral part of every routine physical

examination it is probable that more cancers would be found early. The story of two surgical tragedies resulting directly



FIG. 1. (CASE 1.) Metastasis in bodies of all lumbar vertebrae, causing backache.

from failure to make rectal examinations was indelibly impressed upon me as a student. Dr. Harvey Cushing told of an unnecessary brain operation he had done because a rectal examination had not been made and the primary focus in the prostate discovered, and Hugh H. Young of his first cancer case. A man entered the hospital complaining of a swelling of the tibia. A diagnosis of bone sarcoma was made, amputation followed and microscopic sections showed cancer. A rectal examination was then made and the focus

\* Read before the American Urological Association, Western Division, at Los Angeles, California, Sept. 19, 1930.

was found in the prostate, with few if any symptoms.

The importance of recognizing various

Four cases of carcinoma of the prostate, not diagnosed until unusual metastases had appeared, are reported.



FIG. 2. (CASE 11.) Neck of right femur fractured during manipulation for reduction of "sacroiliac slip." Characteristic "spotty" metastases in pelvic bones. Bladder distended to upper border second lumbar; following the withdrawal of 2000 c.c. of urine, with reduction in size of tumor, patient showed signs of distress so 500 c.c. of water were replaced.

degrees of induration cannot be too greatly emphasized because in carcinoma one almost always finds a third degree induration and such a finding should at once lead to suspicion of malignancy. Occasionally, however, the cancerous prostate is neither nodular nor hard on simple rectal palpation. A cystoscope in the urethra and a finger in the rectum will then be of help, as the stony hard posterior lobe can be felt. Benign hypertrophy is almost never found in the proximal sub-urethral portion of the prostate, hence an extremely hard layer between the apex and verumontanum may be considered diagnostic of carcinoma.

In all cases where carcinoma is suspected x-ray plates of the bones, especially the vertebrae and pelvis, should be made. The metastases are more often productive than destructive. They are indicated by areas of condensation usually multiple, small and closely set, giving a peculiar "spottiness" to the bone.



FIG. 3. (CASE 11.) "Industrial backache" due to vertebral metastases with compression fractures of body of twelfth thoracic, first and second lumbar vertebrae.

CASE 1. (No. 1886) Unrecognized fracture of right femur following frequent manipulation of so-called sacroiliac slip. L. B., age fifty-three, Italian, laborer. On Feb. 12, 1930, while performing his regular duties he felt a pain across the lower back. The following morning he noticed "rheumatism" in his arms, shoulders, neck, back and right leg. Routine daily treatments were given him by his family doctor, but as the pain persisted he came to San Francisco on April 1 to consult a specialist. A diagnosis of sacroiliac slip was made, and this was "reduced" by manipulating the right leg and he was sent home to an osteopath who continued treatments. Subsequently, he was hospitalized four times in San Francisco.

On May 29, because of abdominal pain, he was examined by a consultant who discovered an abdominal tumor held down by a tight sacroiliac belt. I then saw him and found a bladder extending above the umbilicus and an overflow incontinence. The prostate was small and stony hard. There was a marked

anemia; hemoglobin 45 per cent, red blood corpuscles 2,370,000; white blood corpuscles 7400. X-ray plates were made and the roentgenologist (J. R. O'Neill) reported, "extensive osteoplastic metastases in all bodies of vertebrae (Fig. 1) of lumbar spine and pelvis. These changes are characteristic of metastatic lesions in the malignant prostate; also, pathological fracture through neck of right femur" (Fig. 2). Death occurred on July 29, 1930, following the spontaneous rupture of an ischiorectal abscess. *Comment:* No symptoms attributable to the prostate or bladder were noticed by the patient until about three months before death.

**CASE II.** (No. 1953) "Industrial backache" due to metastases in vertebrae from cancer of prostate. (Reported through courtesy of Dr. Ralph Swarts.) C. J., aged sixty-five, single, laborer. On Nov. 9, 1929, while at work, the patient stumbled and fell over backward striking his head on the ground. He continued with his duties throughout the day but the next morning his hips were so sore he could hardly get out of bed. He spent about a month in each of three hospitals and the attendants in the last institution eventually decided that he was a malingerer. His only complaint at this time (Feb. 5, 1930) was "a pain in my right thigh that starts just above my right knee and extends upward to the groin." Examination by the attending physician showed nothing of interest except an enlarged liver, lumbar spine flattened, motion restricted, right sciatic nerve tender, practically no adduction of left femur. Local x-ray diagnosis was "multiple arthritis" (Fig. 3). The film was then sent to San Francisco and Lloyd Bryan reported, "The film shows irregular mottled increase in the bone density with small areas of rarefaction involving the eleventh and twelfth thoracic vertebrae, the entire lumbar spine and the upper sacral segments. There is compression of the body of the twelfth thoracic and first and second lumbar vertebrae. The second lumbar is compressed and is narrowed on the right side. Conclusion: Pathological fracture of the twelfth thoracic and first and second lumbar vertebrae occurring in a metastatic malignancy with a primary in the prostate."

The local physician did not accept this diagnosis so arrangements were made for a trained pathologist to go from San Francisco

to perform an examination and get the prostate, in case of death. However, on April 25, 1930, an autopsy was performed by the

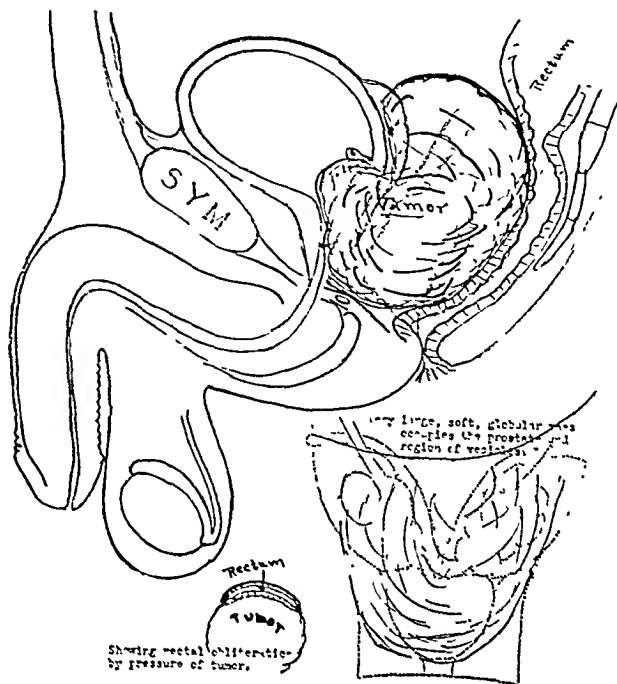


FIG. 4. (CASE III.) Sarcoma of prostate. Diagram of findings at examination.

physician himself, no microscopic sections were made, no specimens saved, no primary focus was reported, but "the eleventh and twelfth thoracic, first, second and third lumbar bodies were very much softened and bore macroscopic evidence of a carcinoma." *Comment:* A sixty-five year old man with no urinary symptoms and an unexplained pain in the back that prevents him from working should be suspected of having bony metastases from carcinoma of prostate. Furthermore, a negative rectal finding made by an untrained finger is worthless.

**CASE III.** (No. 868) Sarcoma (or anaplastic carcinoma) of the prostate. J. E. A., aged sixty-two, married, examined Oct. 26, 1926. Nocturia two times during past eighteen months; catheterized for acute retention five times in past five months. Stream had been getting smaller, was of poor force and there was slight hesitancy but no dribbling. No hematuria until day of examination. *Examination:* Prostate was very large and globular encroaching upon the rectal space so that with great difficulty a finger was introduced. It was very elastic and had the sensation of a cyst (Fig. 4). A cystoscope was introduced with great difficulty, the end having to be depressed almost against

the table and this put a great pull on the suspensory muscle. There was a residual urine of 60 c.c. and a bladder capacity of 350 c.c.,

grumous material. Small lobules of benign prostatic hypertrophy were removed and routine prostatectomy closure, with urethral

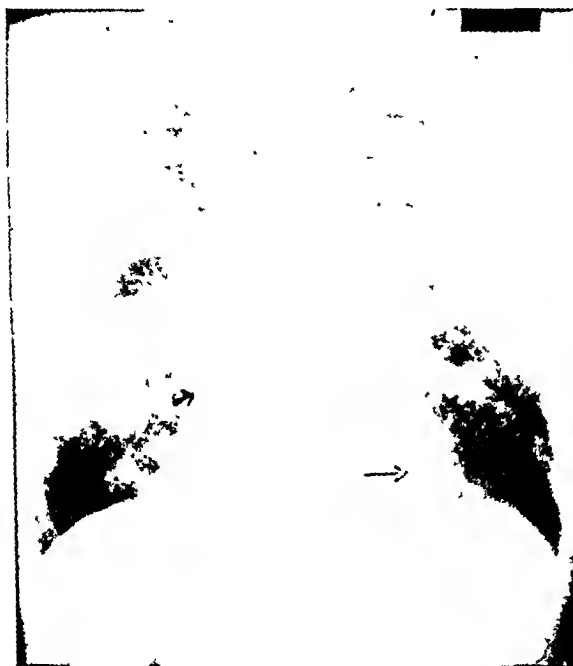


FIG. 5. (CASE III.) Early pulmonary metastasis.



FIG. 6. (CASE III.) Condition found three years later, lungs not having been exposed to deep therapy in interim.

moderate degree of trabeculation; trigon elevated in such a way that neither of the ureteral orifices could be seen. Anterior and lateral clefts were not marked. When an attempt was made to feel the thickness of the prostate with the instrument in the urethra and finger in the rectum, it was found that the finger had to be turned down so that the coccyx was palpated instead of the back of the cystoscope, it being impossible to rotate the finger so as to turn the tip upwards. Tentative diagnosis: Sarcoma of the prostate.

Because of the patient's yellow color simulating jaundice he was thoroughly examined by an eminent internist before the operation, but x-rays of the chest were not made. This physician was rather insistent that we were dealing with a cyst and that it should be aspirated through the rectum. On Nov. 8, 1926, a perineal exposure was made by Young's technique. It was difficult because of the adherent rectum. As the rectum was being dissected away from the prostate the sac tore and there was a gush of what appeared to be dark colored blood, which contained masses of



FIG. 7. (CASE III.) Six months after Fig. 6, one course of deep therapy in interim. There have never been any subjective pulmonary symptoms.

catheter, carried out. Sections of the semi-liquid pus-like material showed "densely



crowded atypical cells supported by a very delicate stroma consisting almost entirely of capillary blood vessels. The cells adjoining

Cystoscopy showed marked invasion of the bladder by the tumor.

On Dec. 3, 1929, he reported that his wife



FIG. 8. (CASE III.) No osseous metastases found until three and one-half years after they had appeared in the lungs.

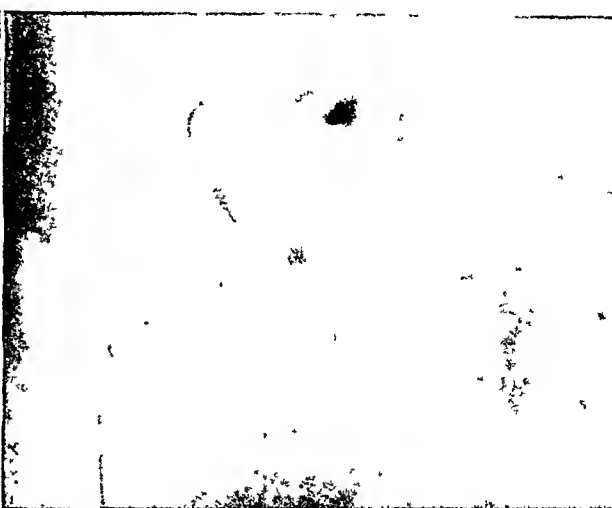


FIG. 9. (CASE IV.) Pathological fractures, left pelvic rami. There are no metastases on right side of pelvis but head of right femur is involved.

some of the capillary spaces show palisade-like arrangement. Mitotic figures were quite frequent. The malignant character of the new growth is well established, probably it will have to be classified as an endothelioma (C. O. E. Werner)."

The x-ray showed no metastases to bones, but "both lung fields (Fig. 5) are diffusely sown with an innumerable number of small faint round rather densely contoured shadows more numerous toward the bases, the largest of which lies just below the heart—diffuse carcinosis (J. Rehfisch)."

Deep therapy was given to the pelvis, the roentgenologist, however, advising against treating chest unless the pelvic tumor responded as he considered the case otherwise hopeless. (Several years before a roentgenologist made a grave mistake on a member of the family, both as to diagnosis and prognosis, and as a result it was very difficult to make them accept a serious view of this case.)

There was no recession in the size of the pelvic mass, but the patient regained his strength and returned to his regular duties. On March 2, 1928, the rectal mass was as large as before operation, and as he was called to Washington, D. C., on business a week later, I arranged for him to go to Baltimore to see a urologist, and take some deep therapy treatments, but he did neither. He was next seen on July 7, 1928, complaining of hematuria.

had put him on chiropractor McCoy's diet of milk and orange juice (as recommended in the daily press) for stomach trouble. It relieved



FIG. 10. (CASE IV.) Pulmonary metastases.

his gas but reduced his weight until he was very weak. (RBC 3,500,000.) He then consented to take another course of deep therapy. On Dec. 4, 1929, the roentgenologist reported (Fig. 6). "There are rounded smooth coin-like shadows fairly uniformly distributed throughout both lung fields. These are slightly more numerous in the base of both lungs and are due

to metastatic malignancy. There is an unusual picture of metastases arising from the prostate but is more likely metastases coming from a testicular tumor (Lloyd Bryan).” Following his second deep therapy treatment he developed a rectovesical fistula and on Jan. 29, 1930, he had a hemoglobin of 40 per cent and RBC 2,000,000.

In May, 1930, he was confined to his home for ten days with influenza. In August roentgenograms showed an improvement of the lung condition (Fig. 7), but there were three small spots in the pubic bone (Fig. 8), the only metastasis in the osseous system. Another course of deep therapy was started but following the first two treatments he had hemorrhages from the bladder, the second being very severe, so the course has not been finished. There never have been any lung symptoms, although one would expect it from the chest films. *Comment:* Sarcoma or anaplastic carcinoma of the prostate. The metastases to the lungs suggest sarcoma. Deep therapy acts favorably on the lung metastases but following one treatment a rectourethral fistula developed and after others severe vesical hemorrhages.\*

CASE IV. Pathological fracture of pelvic rami weakened by metastasis from carcinoma of prostate. (Reported through courtesy of Drs. Prince and Lartigau.) E. M., aged fifty-five, married, merchant. On Nov. 25, 1928, while on a picnic, this patient's hat blew off and into a field. He attempted to crawl under a wire fence, stumbled, his legs were thrown into the air and he felt a snapping sensation in his left hip. He rode home, a distance of more than fifty miles, in an automobile, in comparative comfort. His urinary history is unimportant; there has been occasional nocturia, rare frequency, no hesitancy, no dribbling, urinary stream of good force, no history of hematuria or the passage of stones. Rectal examination showed a prostate slightly larger than normal and stony hard in consistency. His present weight of 187 lb. is his maximum for the past ten years, the average being 180 lb. His

\*He continued to perform his regular duties up to within three weeks of his death which occurred Jan. 24, 1931.

physical examination was essentially negative except for his pelvic condition. The blood Wassermann test was negative. X-ray pictures (Fig. 9) showed a “fracture of the inferior ramus of the left pubis and the descending ramus of the left ischium. There is a marked irregular sclerosis of the bones of the left half of the pelvis and of the right femur. There is considerable coarse mottling throughout both lung fields (Fig. 10). There is irregular mottling with increase of density in the body of the first lumbar vertebra. Condition is due to metastasis from malignant prostate. There is no evidence of bony changes in radiograph of the skull (Lloyd Bryan).”

This patient was given courses of deep therapy over both the pelvis and the lungs. He remained in bed from four to five months and then returned to his regular duties. He reports at the present time that he is in better physical condition than he has been for years, and so far I have been unable to have him come in for a check-up.

#### SUMMARY

1. Four cases of cancer of the prostate are reported all of which were beyond the possibility of a cure before they were diagnosed.
2. Backache cases should not be routinely diagnosed sacroiliac slip and “manipulated” for fear of breaking a femur weakened by carcinoma metastases.
3. An unexplained persistent backache in a man past fifty should suggest carcinoma of the prostate.
4. The lung metastasis caused no subjective symptoms; those in the vertebrae manifested themselves as backache, while those in the pelvis and the femur were silent until fractures occurred.
5. The treatment should be conservative, no surgery being done except for symptomatic relief. Deep therapy should be given routinely as bone metastases so treated may cause no subjective symptoms for eleven years, or more.



# A NEW ENDOVESICAL INSTRUMENT\*

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**W**HENEVER one can avoid an open operation it is logical and desirable to do so. To this end I

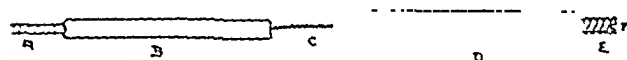


FIG. 1. Female shaft D separated from the male shaft B, showing proximal end of wire C coming through sheath of the electrode A and through male shaft.

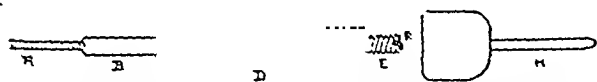


FIG. 2. Female shaft slipped over male shaft and end of wire turned down on threaded post of female shaft at E. Cap G when screwed on to the post E will secure wire to post E.



FIG. 3. Mechanism assembled and ready for use.

have devised the electrode described here which I have found an extremely useful instrument.

It is not the purpose of this paper to decide the indications for the use of this type of electrode, nor does it mean to supplant all open operations in the removal of intravesical tumors, but rather to describe the construction of the instrument and how it is used. Where surgical diathermia is indicated, there are, however, a certain group of selected cases in which this electrode will obviate an open operation.

This electrode is of the loop type and its principle is that of the cutting current of diathermia. The cutting loop electrode, though widely used in surgical diathermia, has never been used in cystoscopic procedure.

The scope of its use will vary from the removal of simple polypi, which is greatly facilitated with this method, to the removal of broader based neoplasms. It has been necessary in the removal of broad based neoplasms by surgical diathermia

to either fulgurate the mass bit by bit, or resort to an open operation of the bladder, "looping" out the mass with a loop

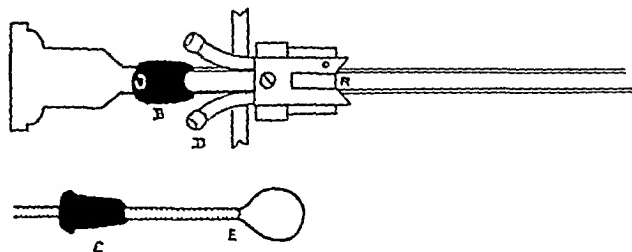


FIG. 4. Upper figure is operating shaft of cystoscope with channels indicated by B-A and D-A. Lower figure shows distal end of electrode with small rubber stopper C on sheath and loop in place.

electrode. By use of this new electrode through a cystoscope, it is now possible to "loop" out an intravesical mass without opening the bladder. This electrode has great variability and will operate through many planes. The loop can be made larger or smaller within the bladder. It can be further manipulated by the drawing up or pushing through of the wire within the sheath of the electrode; advancing or withdrawing the whole electrode; manipulation of the beak of the cystoscope; manipulation of the cystoscope itself; or any combination of any of these movements.

Bleeding of the cut surface is controlled by the current employed. In simple pedunculated polypi, the ordinary cutting current is used. If there be some bleeding at the base, the loop may be touched to or drawn across this point while a coagulating current is sent through. Where one deals with the larger and more vascular tumors the coagulating current is increased. In this procedure the stroke of the loop is slower, allowing fuller coagulation as the loop passes through the mass. Also, if one wishes to further insure against bleeding, an area of coagulation may be sent into the base before cutting the tumor.

\* Submitted for publication September 30, 1930.

This procedure is not for the inexpert or one unfamiliar with the manipulation of the cystoscope and its accessory instru-

2 F. When the cap G is screwed onto this post (Fig. 3), the wire is fixed to a unit consisting of the shaft D and the cap G.

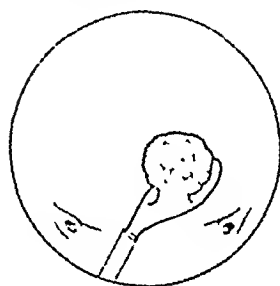


FIG. 5.

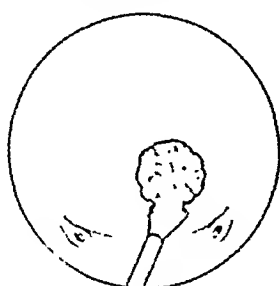


FIG. 6.

FIG. 5. Cystoscopic view of polyp at base of bladder and loop placed over tumor.

FIG. 6. Same as Fig. 5 but showing loop made smaller to fit close to base of pedicle and instrument ready for cutting.

ments. With the wide variation, the many combinations of movements through different planes and with a little care, there need be no fear of penetration of the bladder wall, and I believe the surgeon will find this electrode a useful addition to his armamentarium.

#### CONSTRUCTION

There are five parts which make up this electrode (see Figs. 1 and 2).

1. A wire C with a looped end.
2. The sheath A made of woven silk as in ordinary electrodes.

3. A male shaft B fixed to the proximal end of the sheath and through which the wire C extends.

4. A female shaft D which slides freely over the male shaft B and having at its proximal end a threaded post E.

5. A cap G which screws onto the post E at the proximal end of the female shaft. This cap has a tip H for connection to the cord leading to the energizing apparatus.

The wire C is inserted at the distal end of the sheath A and passed through it and the shaft B until the base of the loop just touches the distal end of the sheath (Fig. 4 E). The female shaft D then is slipped over this wire and the male shaft (Fig. 2 B). The end of the wire is turned down on the post (E) as in Figure



FIG. 7. Entire instrument assembled and showing a polyp, which has just been cut away, attached to loop.

Since the wire is fixed to this unit and is entirely free within the rest of the electrode, advancing and retarding the shaft D on the shaft B will cause a corresponding movement to the loop. By retarding the female shaft, the loop is drawn into the sheath A and made smaller. If one wishes to make the loop very broad, the entire electrode is advanced through the cystoscope while the distal arch of the loop rests against the bladder wall. The wire is sufficiently flexible to conform to this pressure and so flatten the loop. The frequent use of this electrode will eventually cause fraying at the end of the sheath A. This is very simply remedied by snipping off the frayed end with a scissors.

The insertion of the electrode is best accomplished with the operating shaft of the cystoscope removed from the cystoscope sheath.

Before inserting the wire into the electrode, a rubber stopper is slipped onto the sheath of the electrode. If the electrode is to be passed through the operating channel of the cystoscope, the ordinary large rubber stopper (Fig. 4 B) or a small rubber stopper reversed (Fig. 4 C) is used. The loop may then be passed through the operating channel at B to emerge at A (Fig. 4). With the electrode well down on the operating shaft the unit may be replaced into the sheath of the cystoscope and the instrument is then ready for use. Should the operator employ a catheterizing cystoscope, the sheath of the electrode

is inserted into the catheterizing channel (Fig. 4 D), with the rubber stopper on the sheath in the ordinary direction, and

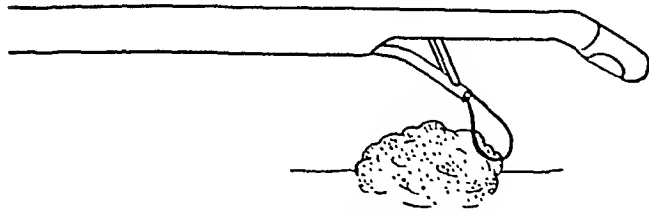


FIG. 8. Loop placed at distal side of tumor and ready to cut off a section.

the wire threaded through the electrode sheath *after* the electrode is in place on the operating shaft of the cystoscope. With the instrument in place, the electrode can be operated through many planes as described earlier in this paper.

Figure 5 shows a cystoscopic view of a pedunculated tumor with the loop of the electrode slipped around the tumor. In Figure 6, the loop has been made smaller to encircle the base. As the cutting current is sent through the electrode, the whole electrode is retarded through the cystoscope and the tumor will be cut away at the base of the pedicle leaving a clean flat surface. Figure 7 shows a photograph of a similar tumor which was located at the upper and right lateral wall of the bladder in an adult male. This was a bleeding polyp and found to be a papillary carcinoma (Grade II). When I removed this polyp, it came away attached to the loop as shown in the photograph.

The method of approach with broader

based neoplasms is indicated by Figures 8 and 9. The loop is placed at the distal portion of the tumor (Fig. 8). If the tumor

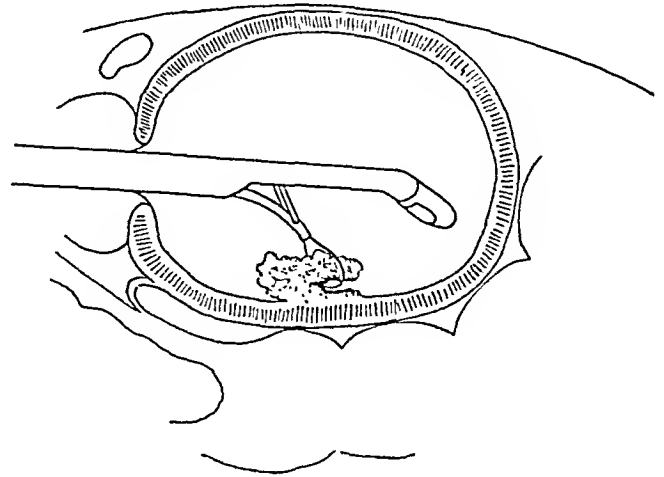
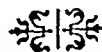


FIG. 9. Loop cutting through tumor.

is not large, a good part of it will be cut through by the sweep of the loop when the beak of the cystoscope is depressed. This motion may be augmented by a tilting of the cystoscope itself. If the tumor is quite large, as in Figure 9, the cystoscope is retarded with the loop depressed as shown in the drawing.

#### SUMMARY

A new endovesical instrument has been presented with detailed description of its construction and some suggestions as to its use. It is hoped that the surgeon will find it as useful an instrument as the author has found it to be.



# CUNEIFORM OSTEOTOMY

## A METHOD OF PLANNING DIMENSIONS OF WEDGE TO BE REMOVED\*

WILTON H. ROBINSON, M.D.

PITTSBURGH, PA.

CUNEIFORM osteotomy being an operation of election it is possible and desirable to plan in advance the by the writer in 1921<sup>1</sup> and shown in Figures 1 and 2 it is possible, not only to measure the angular deformity, but to lay

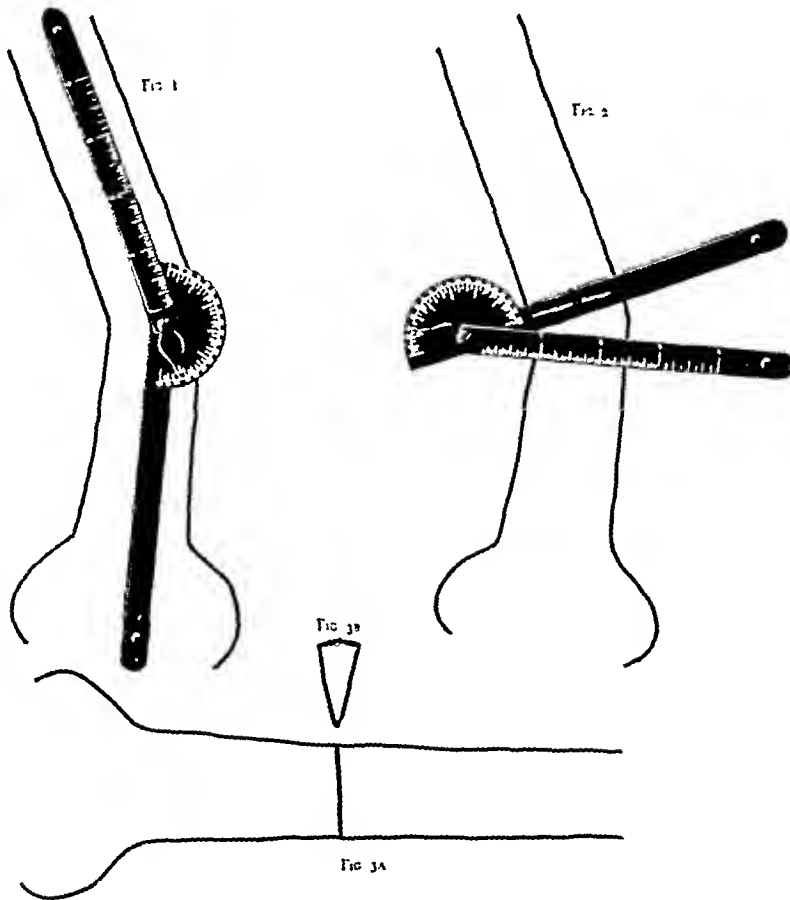


FIG. 1. Protractor placed to show angular deformity.  
FIG. 2. Protractor placed to show dimensions of wedge.  
FIG. 3 A. Effect on the bone of removal of the above wedge.  
FIG. 3 B. The wedge.

size and shape of the wedge of bone to be removed. Such advance care is amply rewarded by reduction in the operating time, by the possibility of obtaining better alignment of the two sections of bone and by the truer apposition of the cut bone ends obtained.

By the use of the protractor introduced

out on an x-ray film or a tracing of the same the exact dimensions of the wedge of bone to be removed.

*Method.* The angular deformity is measured by placing the instrument over the x-ray film or its tracing in such a manner

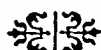
<sup>1</sup> Robinson, W. H. Joint range. *J. Orthop. Surg.*, 3: 41, 1921.

\* Submitted for publication August 29, 1930.

that the axis pin coincides with the point of greatest curvature and the two arms coincide with the axis of the respective sections of the shaft of the bone (Fig. 1). The pointer will now point to the figure indicating the actual angulation. As the scale of this instrument is from 0 to 180 the latter figure being equivalent to a straight line, it is necessary to subtract the reading from 180 to obtain the number of degrees of deflection. Adjust the pointer to indicate this number on the scale. Now, without altering the position of the arm, lay the instrument on the film or its tracing with the apex of the open space between the arms at the point of greatest concavity on the concave side of the bone and the

dimensions of two sides of the proposed wedge will be indicated by the inner edge of the two arms while the third side will be shown as the convex line of the bone between the arms.

*Example.* In the illustration the angular deformity is  $155^{\circ}$  which subtracted from  $180^{\circ}$  leaves  $25^{\circ}$  as the actual deflection. Placing the pointer at  $25^{\circ}$  on the scale and placing the instrument on the x-ray film or outline tracing shows the angle of two sides of the wedge between the arms of the instrument and the third side on the convex side of the bone between the two arms. The length of this third side is (on the tracing used)  $\frac{1}{2}$  in. (7 cm.).



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\* Continued from p. 501.

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## EDITORIAL

### THE GENERAL SURGEON AND SURGICAL PATHOLOGY

THE day has arrived when the general surgeon must of necessity become a student in surgical pathology. Surgical pathology has made marked strides in progress during the past two decades. The general surgeon of today fully realizes this fact and recognizes that if he is to give the best possible in surgery to his patient he must fully understand the microscopical development of the condition for which he operates.

The sounder and more thorough the understanding of the principle of the underlying microscopical development making it necessary to operate the more effective and satisfactory will be the work of the general surgeon. If the general surgeon does the best possible in his field of endeavor in any case he must have this

understanding of the development of the condition for which he operates.

The day has also arrived when the public expects an accurate opinion as to the prognosis in surgical conditions. No general surgeon can give a properly outlined prognosis without being able to study microscopically the tissue in question. The microscope should be the third hand of every general surgeon. All tissue removed at the operating table should be sectioned for study by the general surgeon who operates.

For years the general surgeon has acquainted himself with the macroscopical appearance of specimens obtained at the operating table. It has become his custom to carefully study these gross specimens and visualize the comparison of simi-



lar specimens obtained from other like operations.

Now the time has arrived when this general surgeon is no longer content to let his personal study end in the gross findings. Possibly the intensive campaign against malignancy has been responsible for this present feeling among general surgeons. We are bound in the future to be better able to combat much more effectively the various types of malignancy to which the human race is subjected.

Medical schools will in the near future establish schools of instruction in surgical pathology where the general surgeon can go to acquaint himself with this line of endeavor so closely allied to his everyday life.

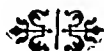
Joseph Colt Bloodgood of Johns Hopkins University is one of the outstanding figures in the field of surgical pathology. His personal untiring efforts of the past few years coupled with his ability to organize has made it possible for the general surgeon to become a student in surgical pathology.

Especially in dealing with a questionable malignancy every general surgeon should have the portable frozen section table equipment at hand and even while the

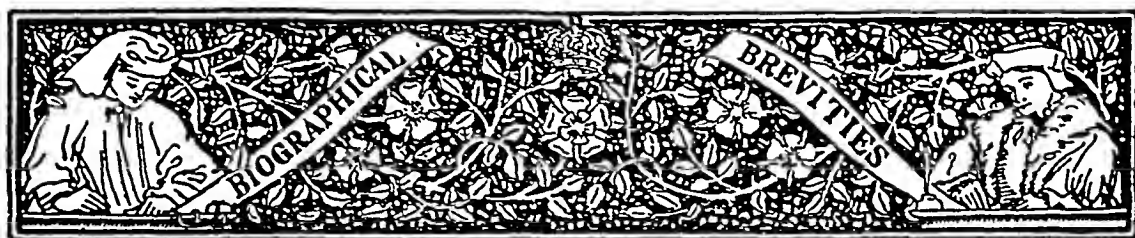
operation is going on he can personally study under the microscope the tissue he is removing. Thus can the general surgeon more intelligently and with better judgment decide what type of operation and the extent of the same is best for the case in question.

We are making rapid progress in all lines of medical science, yet, none stands out more prominently in this advance than does microscopical study in collaboration with surgery. If we are to meet with better success in the future especially in lowering the present-day mortality due to malignancy our fort lies in every general surgeon's becoming a student of surgical pathology. The study of tissues under the microscope, the early recognition of malignancy microscopically in its very early stages, the complete removal of these cancer cells and the ability to differentiate these tissues at the time of operation are our present hope for lowering the mortality rate from this disease. The general surgeon who becomes a student of surgical pathology is the individual who will be fitted to render such a service to humanity.

G. S. FOSTER.



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## "ROENTGEN RAY"

**W**ILHELM CONRAD ROENTGEN was born on March 27, 1845, in Lennep, a town in the industrial section of Germany.

His father was a manufacturer of cloth. Roentgen's mother was Dutch. Her people were well known in shipping circles.

Wilhelm Roentgen was an only child. Born of cultured parents he acquired a love for the beautiful which held his interest throughout his life.

As a very young boy he lived in Holland with his mother's relatives; later, he moved with his parents to Apeldoorn and attended school in Utrecht. He was commonplace as a student. He was placed in a school for machinists so he could prepare to enter his father's factory. He took the examinations to enter college but failed. A friend informed him he could enter the Zurich Technical High School without the usual credentials. Roentgen entered this school and there Clausius, Professor of Theoretical Physics, and Kundt, the experimental physicist, instilled such an interest for the physical sciences in Roentgen's heart that soon he was devoting all his energies to this subject. On June 22, 1869 he was graduated with the degree of Doctor of Philosophy. He accepted a position as assistant to his teacher, Kundt. Somewhat later Kundt accepted the chair at Wurzburg and Roentgen followed him there. While in Wurzburg he married Bertha Ludwiz. They never had children but adopted a young niece of Mrs. Roentgen's.

Kundt went to the newly founded university in Strassburg and Roentgen

went with him. On March 13, 1874, Roentgen became Privatdozent of Physics. A year later he accepted the chair of physics and mathematics at the Academy of Hohenheim. He was not happy here and a year later returned to work with Kundt as Associate Professor of Theoretical Physics. He and Kundt published some excellent papers which led to the offer which he accepted of the chair of physics at Giessen University. He remained there ten years. He did some of his best work at Giessen and often referred to his days there as the most happy ones of his life. In 1888 Roentgen succeeded the brilliant Kohlrausch at the University of Wurzburg. A few years previously this university had refused to give Roentgen his academic standing. It was while at Wurzburg he made his discovery of the x-rays, in November, 1895.

The "discovery" was the result of years of work and the work of many scientists which Roentgen correlated. Roentgen named his discovery the x-ray.

His honors were many. Universities vied in their attempts to get him on their staff. He remained at Wurzburg until April, 1900, when he accepted the chair at the University of Munich by special request of the Bavarian government. In 1901 he was awarded the first Nobel prize.

The war broke his spirit. He loved his fatherland. His wife, whom he dearly loved, died on October 31, 1919. Most of his friends were gone. Sad of heart, Roentgen died of a carcinoma on the intestines on February 20, 1923, at the age of seventy-eight years.

T. S. W.



WILHELM KONRAD ROENTGEN

[1845-1923]





[From Fernellius' *Universa Medicina*, Geneva, 1679.]

# BOOKSHELF BROWSING

## BEACON LIGHTS IN ALABAMA\*

L. L. HILL, M.D., LL.D., F.A.C.S.

MONTGOMERY, ALA.

AS Dr. Weir Mitchell said of Benjamin Franklin, he came from Boston but was born in Philadelphia at the age of seventeen; so I say of Marion Sims, he came from South Carolina but was born in Alabama, in 1835, at the age of twenty-two years. Before coming to Montgomery Dr. Sims located at Mt. Meigs, a little village thirteen miles distant. It was a long way from the hovel of the negro slave at Mt. Meigs, Alabama, to the boudoir of the Empress Eugénie in the magnificent palace of St. Cloud where Dr. Sims had professional supervision of the Empress's health. He was especially skilled in plastic surgery, being a mechanical genius, and did successfully all of the capital operations of his day and time including those of the eye. As an operator he was skillful, resourceful, and thoroughly self-possessed, but there was in his work none of the aggressive, dramatic clock surgery of Baron Larrey, who on that frightful field of Borodino, in 1812, amputated 200 limbs in twenty-four hours, and had 7 recoveries out of 11 shoulderjoint disarticulations. This was before the discovery of anesthesia or antisepsis, and it has been said a minute was Baron Larrey's usual time for an amputation and 25 per cent his mortality. Dr. Sims though usually successful had

his calamities. Lawson Tait in speaking of "bad luck in surgery" always mentioned Sims' operation on a case of vesicovaginal fistula at the Samaritan Hospital in London and how six days later at the post mortem it was found he had inadvertently closed the ureters, as well as Burdon-Sanderson's discovery on post mortem that Sir Henry Thompson had left in the bladder of Napoleon III an uncrushed stone weighing  $3\frac{1}{4}$  oz. In 1845 a woman was thrown from her horse and suffered a retroversion of the uterus and while correcting the displacement Sims discovered the effect of atmospheric pressure in the vagina that led to the invention of Sims' speculum, Sims' position, a special suture of silver wire, a catheter, and the cure of vesicovaginal fistula. This was the "tide in the affairs" of Dr. Sims "that was taken at the flood and led on to fortune." His first three operations, all of which were successful, were performed upon negro women, Anarcha, Lucy, and Betsy. The names of these three colored women will be irrevocably associated with the memory of J. Marion Sims, as will the name of Joseph Meister, the Alsatian boy, be associated with Pasteur, that of Venable with Crawford W. Long, that of Alexis St. Martin with Beaumont,

\* Submitted for publication March 14, 1931.

and that of the twenty-five year old man with Lister upon whom, with the aid of his antiseptic system on April 11, 1868, Lister produced artificially a compound fracture into the anklejoint and restored an absolutely useless limb. Born the year Beethoven died, Lister's life was the exemplification of the closing lines of the great composer's immortal ninth and last symphony, "Millions loving I embrace you, to the whole world this kiss I send." Lister, who converted surgery, a near massacre, into a healing art, left us the richest legacy of all the dead. It has been said some things are immortal: the plays of Shakespeare, the marbles of the Greeks, and the music of Wagner, and I will add the speculum of Sims; no one in eighty-five years has been able to make the slightest improvement upon it. In 1861 Dr. Sims demonstrated his method of operating in most of the great cities of the world. How different was the altruistic spirit of Marion Sims from that of John Abernathy who, until Thomas Wakley appealed to the courts, lectured to his students in the dark to prevent his methods from being given by the London *Lancet* to the profession, or from that of Johannes Jacobus Rau, of Amsterdam, who dissected the bodies of the patients that Frère Jacques had lost after his lithotomies and discovered that the improved operation consisted in dividing the prostate and neck of the bladder. Rau kept this a profound secret and taught his students that he still cut through the posterior wall of the bladder, a much more dangerous operation. Albinus, a pupil of Rau who had been thus deceived, taught Cheselden in England to cut through the posterior wall but Cheselden soon discarded this as unsatisfactory and devised an operation upon correct anatomical lines which he usually performed in a minute. Sir D'Arcy Power says Cheselden's operation was popular in Europe until 1885 when lithotomy came in vogue. It might be of interest to recall it was Cheselden's operation that Dr. Physick was taught by John Hunter

and which he performed upon our great Chief Justice John Marshall, removing a thousand stones from his bladder. Of course we all know that the Liberty Bell was cracked, in 1835, while tolling for the great Chief Justice, but that was four years after Dr. Physick's operation. Sims was a pioneer in gall-bladder surgery and gave us the name of cholecystotomy in 1878. There was in the many-sided make-up of Dr. Sims "the pert and nimble spirit of mirth." When he lived in Montgomery one of his children born on Christmas day was promptly named "Merry Christmas." Dr. Sims removed to New York in 1853 and founded the Woman's Hospital in 1855. He died in New York City in 1883. There is a statue of him in Bryant Park, New York, and a memorial tablet in Montgomery, Alabama, erected to his memory at 21 S. Perry Street where his hospital was located and where he did the first successful operation for vesicovaginal fistula. Montgomery, Ala., claims to be the birthplace of gynecology with J. Marion Sims as the parent.

Though Alabama claims Dr. Josiah Clark Nott, just as J. Marion Sims, he came from South Carolina, and was graduated from the medical department of the University of Pennsylvania, while Sims was graduated at Jefferson Medical College. In 1844, in the *New Orleans Medical Journal* Nott described the condition and Sir James Y. Simpson, in 1861, gave the nomenclature, coccygodynia. Samuel D. Gross says that as early as 1832 Dr. Nott first performed a coccygectomy on account of "severe and intractable neuralgia." In 1848, in the *New Orleans Medical Journal* Dr. Nott suggested the "mosquito theory" with reference to the transmission of yellow fever, antedating Carlos Finlay by thirty-three years. In 1859, Dr. Nott founded the Medical College of Alabama and lectured on surgery. He died in Mobile in 1873.

John A. Wyeth was born in Marshall County, Ala., in 1845. He married Dr. J. Marion Sims' daughter, Florence Nightin-

gale, in 1886, and died in New York in 1924. Dr. Wyeth was the founder of the first post-graduate medical school in the United States. In 1890 he demonstrated his bloodless amputations of the shoulder and hip-joints, in 1903 the treatment of vascular tumors by injection of hot water, and in 1909 he was the first to cure sarcoma by streptococcus infections. Dr. Wyeth's "Text Book on Surgery" passed through four editions and greatly enhanced the author's reputation. He was offered the chair of surgery in Tulane University upon the resignation of Dr. T. G. Richardson, the favorite private pupil of Dr. S. D. Gross in Louisville, Ky. Dr. Richardson was celebrated as an anatomist and in 1841 without anesthesia successfully amputated both legs at the hip-joint. Dr. Wyeth declined the offer saying, "It was a great temptation to go back home but my heart was in the work of building up the Polyclinic as a great post-graduate medical school." In 1914 appeared his charming autobiography, "With Sabre and Scalpel." Dr. Wyeth was personally the most popular doctor in the United States and was honored with every great elective office within the gift of the medical profession. There is a statue of him in his operating overalls on the Capitol grounds at Montgomery, Ala. The Civil War ended with Dr. Wyeth at Appomattox. He was loyal to the Union but he could not forget that he had once followed the stars and bars. He wrote the best biography of Lieutenant-General N. B. Forest, a negro trader who without education or military training entered the Confederate Army as a private, became a Lieutenant-General and was pronounced by Jefferson Davis as the genius of the Civil War. When William Dean Howells eulogized Mark Twain and called him the most desouthernized Southerner he ever knew Dr. Wyeth answered that it was true, that when a lieutenant in the Confederate Army Mark Twain deserted and wrote an impudent letter to his commanding officer stating as his reason that his health had

been broken down due to too much retreating.

Dr. Henry S. Levert, of Mobile, Ala., by experiments on dogs showed the innocuous character of lead, gold, silver, and platinum wire for tying arteries. In 1866 his nephew, Dr. C. H. Mastin, of Mobile, who was his assistant, successfully tied the external iliac artery with silver wire.

Dr. Seneca D. Powell was born in Wilcox County, Ala., in 1847. He was a Confederate soldier, in 1869 was graduated from the University of Virginia, and in 1870 from the University of New York, and became chief assistant of the celebrated New York surgeon, James L. Little. Dr. Powell was the discoverer of the fact that pure alcohol instantly neutralizes the caustic effect of carbolic acid. He told his nurse to hand him a 5 per cent solution of carbolic acid with which to wash his hands, and instead she gave him the pure acid; not knowing what else to do he ran his hands down in a pan of alcohol with perfect relief. Starting from this Dr. Powell introduced the carbolic acid treatment of leg ulcers with fine results.

Sir William Osler Boswellized Dr. John Y. Bassett, of Huntsville, Ala., An Alabama Student.

Alabama has furnished four presidents of the American Medical Association, W. O. Baldwin, J. Marion Sims, John Allan Wyeth, and W. C. Gorgas. In 1865 Samuel D. Gross came to Montgomery, Ala., to perform lithotomy and received \$2000.00, which he said was the largest fee he had ever gotten. While in Montgomery he met Dr. W. O. Baldwin, a very able man with a charming personality. Dr. Baldwin was a successful physician, first to discover quinine amblyopia, banker, financier, and an intimate friend of J. Marion Sims and William L. Yancey, the South's greatest orator. It occurred to Gross, who was then in "the noon and zenith of his career and in the flush and glory of success," that to bring about good feeling in the American Medical Association a Southern man ought to be elected president

at the next meeting, and Gross selected Baldwin. Dr. Baldwin's inaugural address was a classic and his administration justified Dr. Gross's selection.

Alabama Medical Association was organized under its present system in 1868. Alabama is the only state in which the Medical Association is a part and parcel of the State government. The Governor of the State is the Chairman of the State Board of Health. Semi-annually the State Board of Censors meets to examine candidates for the practice of medicine in Alabama. These examinations are very rigid. The Health Department was perfected by Dr. Jerome Cochran, a man of great learning and eminently adapted to organizations. A good many foreign doctors come annually to study our system.

The Medical College of Alabama was founded by Dr. J. C. Nott, in 1859, at Mobile, Ala. Nott went to Europe the following year and spent \$50,000.00 purchasing specimens for the museum. Dr. Nicholas Senn said that some of the preparations are "worth their weight in gold and cannot be duplicated." In 1907 the college became the School of Medicine of the University of Alabama, and in 1920

was moved to Tuscaloosa and clinical teaching discontinued.

The Alabama Surgical and Gynecological Association was founded by Drs. John and Elias Davis, of Birmingham, Ala., and held its first meeting in that city, in 1888, with Dr. W. D. Haggard, Sr., of Nashville, as President and Dr. Elias Davis as Secretary. The name was subsequently changed to Southern Surgical Association. A few years ago when the association met in Birmingham it erected in Wilson Park a statue in memory of Dr. Elias Davis.

On May 17 the profession of Alabama lost one of its most popular and distinguished members, Dr. John Davis, of Birmingham, and it was a sad day for me as, to use an expression of Lord Balfour, the roots of our friendship went down into the same past for more than fifty years. Dr. Davis was terribly mangled in an automobile accident and with more than a hero's courage, with more than a martyr's fortitude he bore his suffering, and met the inevitable end that awaits each and all.

Green be the turf above thee  
Friend of my better days  
None knew thee but to love thee  
Nor named thee but to praise.





## BOOK REVIEWS

THE PHYSICIAN OF THE DANCE OF DEATH.  
By Aldred S. Warthin, N. Y., Paul B.  
Hoerber, Inc., 1931.

Fortune is the physician with a hobby, and particularly fortunate is he whose avocation leads him ever onward, away from the narrowing influence of his specialty and into fields of deep learning and rich culture. As Osler once said, medicine is a jealous and exacting mistress, one who usually reserves her favors for those who woo her constantly, and her alone. Perhaps it is for this reason that there have been so few physicians of the stamp of Osler and Holmes and Mitchell, who could become distinguished as men of letters without at the same time dimming their reputations as men of science; and it is for this reason that we welcome with particular pleasure the advent of the new book which now shows that a great pathologist is, at the same time, a thoughtful philosopher and a learned historian.

In Doctor Warthin's foreward he tells of the young medical student who, in 1893, while passing through Nuremberg on his way to Vienna, stopped before a shop window to admire a fine print of Albrecht Dürer's "Ritter, Tod und Teufel." So deep was the impression made upon the youth by this picture that it was purchased, and with it there came an inspiration and an interest that have remained and grown through all the succeeding years. Year by year Warthin has added to his collection examples of every known representation of death in art, and of every known book on the subject, and in spare time he has traced through this material man's ever changing concept of death and of what lies beyond.

The earliest pictures, dating back to 1424, represent death in its most fearsome aspects. This is as one would expect when one takes into account the uncertainty of life in those days. War, pestilence, and injustice were always abroad in the land, and to anyone, horrible death was likely to come at any moment. With churchmen depicting a hereafter in which there was little to look forward to beside unending torment and misery, one can easily see why the men and women of that day pictured death as a hideous fiend:

a bony cadaver who, appearing early and uninvited, dragged his young and unwilling victim down into the pit.

It was only after several centuries that this fear of premature death began to disappear from the artists' pictures, and in its place came the idea of death coming sometimes as a friend of the aged, a friend bringing release from weariness and pain.

Doctor Warthin's study contains much of interest, not only to the historian, the artist, and the man of letters, but to the physician, because it throws so much light on the development of medical practice and prestige. The pictures show first the popular contempt for the quack with the ever present urinal held up to the light; they show his dress, and in many ways they indicate his low social position. Gradually, as time progressed, the urinal disappeared, the physician became better trained and more dignified, and his social position accordingly improved.

As time went on and life became less uncertain, the artists became less and less interested in depicting the horrors of death and more and more concerned with cataloging its causes. Finally, there came the great war, and with it a new type of picture showing the horrors of death in the trenches.

Today, the intense fear of death is largely gone; modern man has learned to face his departure from this life with resignation, with bravery, or with cynical indifference. To a large extent he has lost his faith in a hereafter; he refuses to speculate very much about it or to prepare for eventualities, and often he pays little attention to the proffers of help from those who would prepare the way before him in the promised land. Under these circumstances the Dance of Death motif now awaits new treatment at the hands of present day artists.

Typographically, the book has all of the attractiveness which one has come to associate with the name of Hoerber. It is lavishly illustrated and there is an excellent bibliography. The book will doubtless be read by every earnest student of the history of medicine, and by many of the modern group of historians who are interested less in the chronicles of kings and battles and more in the thoughts and lives and customs of the common people.

SELECTIONS FROM THE PAPERS AND SPEECHES of John Chalmers DaCosta, M.D., LL.D., Samuel D. Gross Professor of Surgery, Jefferson Medical College, Phila. 440 pages. Phila., Saunders, 1931.

The feeling of the reviewer in picking up this book is "how did he do it?" Here is one of the busiest and most famous surgeons in America producing a book of over 400 pages with the following table of contents.

Medical Paris During the Reign of Louis Philippe

The Trials and Triumphs of the Surgeon

Address on the Occasion of the Graduation

Exerciscs at the Naval Medical School in

Washington on March 30, 1907

Dickens's Doctors

Baron Larrey: A Sketch

The Old Blockley Hospital: Its Characters and Characteristics

Then and Now

The Old Jefferson Hospital

Character Sketch of Professor Samuel W. Gross, M.D., LL.D.

The Surgeon, The Patient, and The Clinical Diagnosis

Behind the Office Doors. Surgical Oration

Before the Ohio State Medical Association

Crawford W. Long

The Samuel D. Gross Address for 1914-15

William Williams Keen: A Sketch

The Foundation and the Founder of Jefferson Medical College

The Last Surgical Clinic in the Old Amphitheater of the Jefferson Medical College

Hospital, Held Before the Junior and Senior Classes, May 10, 1922, By Professor John Chalmers DaCosta

Facts Concerning the Old Operating Table Certain Tendencies in Medicine

Address at the Opening of the Nurses' College of the Allentown Hospital December 23, 1915

The Personal Side of Pepys

Suicide

Everyone of these articles is full of meat and worth reading, not only for pleasure but for what is to be learned therefrom.

Quoting at random a few short excerpts will perhaps whet the appetite for more of this mental stimuli: "it is interesting to know what men do who give up medicine . . . some go to the devil and some go to Congress," and then there is a whole page of the most interest-

ing comments on this, particularly devoted to interesting answers to these most pertinent questions.

How many are aware that Keats gave up being a dresser in Guy's Hospital and wrote the Ode on a Grecian Urn? The entire chapter on The Trials and Triumphs of the Surgeon should be read and reread by every surgeon interested in his calling. Then in the chapter Behind the Office Doors, we find such phrases as "I am sitting writing among my medical books. One must have at hand books of literature, books for study, books for diverting reading, and books for immediate reference. Unless things are looked up at once, they are seldom looked up at all." Enough of this—we would be tempted to reprint page after page, but must curb our enthusiasm and suggest that you add this book to your library and read every word of it.

SURGERY, ITS PRINCIPLES AND PRACTICE, FOR STUDENTS AND PRACTITIONERS. By Astley Paston Cooper Ashhurst, A.B., M.D., F.A.C.S. Ed. 4, thoroughly revised, 1189 pp., Phila., Lea & Febiger, 1931.

The fourth edition of Ashhurst's "Surgery" is before us, and as in the previous editions, the ground is fully covered and the work is entirely up-to-date.

Of course, no volume of 1200 pages covering the entire subject of surgery, will satisfy any given individual in its entirety. If it did, there would be no excuse for the numerous volumes that are published on this subject with, what seems to the reviewer, appalling frequency.

However, it may truly be said that for a student's textbook and for a quick reference book, Ashhurst leaves little to be desired.

TRAUMATOTHERAPY (TREATMENT OF THE INJURED). By John J. Moorhead, B.SC., M.D., F.A.C.S., (D.S.M.). Ed. 1, 574 pp. Phila., Saunders, 1931.

Dr. Moorhead's new work on "Traumatotherapy" (Treatment of the Injured) covers the ground indicated in the title. The coining of the word "traumatotherapy" and of so many other new words, at the present time, is to be decried.

In less than 600 pages, with 625 illustrations, the author has succeeded in giving the most

important points on the technique of treatment of injuries.

The author states in his Preface that "There is no type of surgery to-day more universal than accident surgery, and in reality we are just beginning to realize that it is a specialty in itself." Why surgical conditions, due to injuries, should be considered from a different aspect from other surgical conditions, is not made clear. It is felt that every general surgeon should be posted on the treatment of injuries as well as on the diagnosis and treatment of other conditions.

The book will be found a handy work of reference.

**OBSTETRICS, A TEXTBOOK FOR THE USE OF STUDENTS AND PRACTITIONERS.** By J. Whitridge Williams. Ed. 6, 1125 pages. N. Y., D. Appleton & Co., 1930.

Through some inexplorable error a review was published in our April issue of the fifth edition of Williams' "Obstetrics." This is one of those errors that *will* occur. We intended to review the splendid new sixth edition of this work which has been entirely reset and entirely rewritten.

This book is particularly strong in the matter of Pathology. There are over 40 new cuts and many of the old pictures have been replaced by new and better ones.

We know of no better book for the student, and it is a splendid work of quick reference for the practicing obstetrician.

**DISEASES OF THE TONGUE.** By Walter G. Spencer, M.S., F.R.C.S., and Stanford Cade, F.R.C.S. Ed. 3, 39 col. illus., 546 pp., Phila., P. Blakiston's Son & Co., Inc., 1931.

This is the third edition of the famous Butlin's "Diseases of the Tongue." It was first published in 1885, translated into German and French, reprinted in 1890, revised by Butlin and Spencer in 1900.

While this book is an entirely new work, the author states very frankly in the preface that "no better foundation for the work could be found than the work of Henry Butlin, who prophesied twenty-five years ago the possibilities of the future, and whose clinical accuracy and surgical skill are still vivid in the memory of those who knew him."

Radium therapy is taken up in detail and,

all in all, the book may be looked upon as the most up-to-date monograph at present available on diseases of the tongue.

**THE DIAGNOSIS AND TREATMENT OF BRAIN TUMORS.** By Ernest Sachs, A.B., M.D. 224 illus., 381 pages, St. Louis, C. V. Mosby Co., 1931.

The number of brain tumors that the average surgeon is apt to see in the course of his active practice may be very few, but there is no question that he should be able to make a diagnosis, and, for this purpose, if for no other, this book will be a valuable addition to the library of any surgeon. It is splendidly illustrated and complete without being verbose. The book is a credit to both the author and the publishers.

**DER KUNSTLICHE PNEUMOTHORAX.** By Dr. Hanns Alexander. 42 pp., Berlin, Julius Springer, 1931.

In a pamphlet of 42 pages, based on a lecture delivered at the Sauerbruch Clinic in Berlin, the author discusses the present status of the artificial pneumothorax. The work is based, particularly, on the author's article on the same subject in Sauerbruch's "Chirurgie der Brustorgane."

There is no bibliography and no index but there is a very complete table of contents. There are 45 splendid illustrations.

**DIAGNOSTIC METHODS AND INTERPRETATIONS IN INTERNAL MEDICINE.** By Samuel A. Loewenberg, M.D., F.A.C.P. Ed. 2, revised, 1032 pp., Phila., F. A. Davis Co., 1931.

This book is published on transparent paper which makes very difficult reading.

The scope of the book is amply described in its title.

The young physician will find this book a very practical one to have on hand for quick reference. Much advice is given in interpretation that should prove invaluable to the beginner. There are over 500 illustrations and an index of 50 pages.

**CRIPPLED CHILDREN.** By Earl D. McBride, B.S., M.D., F.A.C.S. 280 pp., St. Louis, C. V. Mosby Co., 1931.

This volume, intended primarily for the

instruction of orthopedic technicians, nurses, and social workers, is nevertheless an important contribution to medical literature. Its phraseology is that which a semi-professional person is presumed to be able to understand; its content is such that the general practitioner of medicine would find helpful in the diagnosis and management of this class of cases.

The book abounds in technique, a matter which is notoriously variable with regard to habitat, tradition, and experience. The technique is on the whole sound, and admirably serves its purpose in the instruction of those to whose service it is dedicated.

Since the note of prevention is so frequently stressed in these pages, an exception to the teaching contained in the volume might be here singled out for special mention. Congenital dislocation of the hip is still considered as existing in the Lorenz era. It is now known that a reconstitution of the joint to normal is possible only at ages less than half the author's eight to nine year limits.

**THE DIET BOOK, FOR DOCTOR, PATIENT AND HOUSEWIFE.** By Marguerite Requa Rea. 188 pp., London, Humphrey Milford, 1931.

This book on diets has a splendid array of recipes, which, under the proper guidance of the attending physician, will be found invaluable by the nurse or attendant of the patient.

Published in London, the book is, of course, more suitable for Great Britain than for America. Little fault, however, will be found with the various diets, many of which are in accord with American standards and, all in all, the book will be found an interesting one for the physician to have on hand when making his dietary recommendations.

**A HANDBOOK FOR SENIOR NURSES AND MIDWIVES.** By J. K. Watson. Ed. 2, N. Y., Oxford Univ. Press, 1931.

This book of 676 pages, in its second edition, is one of those carefully done things that have the appearance of authority on every page. In this country it will prove valuable to those in the nursing profession. It covers a wide range of subjects. Part One deals with medical problems: cancer, blood and health, the ductless glands, constipation, smallpox, even intracranial tumors; Part Two with surgical condi-

tions; Part Three treats of Children, with chapters on Infant feeding, adenoids, convulsions, tuberculosis, pneumonia (this gives an idea of this section of the book). Part Four handles Obstetrical Conditions and is well written and should be read by every trained nurse. The book ends with a section covering Gynecological findings: Menstruation and its abnormalities, Fibroid tumors of the uterus, Cancer of the uterus, and The Commoner Affections of the uterus other than fibroid and malignant tumors.

There is an index.

**THE SCIENCE AND PRACTICE OF SURGERY.** By W. H. C. Romanis, M.A., M.B., M.Ch., Cantab., F.R.C.S. (Eng.), F.R.S. (Edin.), and Philip H. Mitchiner, M.D., M.S. (Lond.), F.R.C.S. (Eng.). Ed. 3, 772 pp., N. Y., Wm. Wood & Co., 1930.

This is the fourth Practice of Surgery that has passed through the reviewers hands within the past few weeks. It is unfortunate that new editions and new books on similar subjects so often appear about the same time. How much more desirable it would be if they could be published say, a year apart, each one thereby being able to record any slight advances during the previous year! However, while this idea would appeal to the reader of books, it would probably not make a hit with the authors and publishers of the individual volumes.

As the authors state in their preface: "The call for a third edition within two years of the appearance of the second edition testifies to the utility of this work to the practitioner and student of surgery." This is quite true, and is ample justification for the issuance of these volumes, which may be accepted as presenting, particularly, the English point of view at the present moment.

**DAS POLLERSCHE VERFAHREN ZUM ABFORMEN, AN LEBENDEN UND TOTEN SOWIE AN GEGENSTANDEN.** By Dr. Med. Alphons Poller. 210 pp., Berlin, Urban and Schwarzenberg, 1931.

To those interested in making casts, Dr. Alphons Poller's book "Das Pollersche Verfahren Zum Abformen" will be of inestimable interest and value. The technique is explained with typical German thoroughness and the illustrations are well chosen.

PRACTICAL ANAESTHETICS, FOR THE STUDENT AND GENERAL PRACTITIONER. By Charles F. Hadfield, M.B.E., M.A., M.D. Camb. Ed. 2, 336 pp., New York, Wm. Wood & Co., 1931.

According to the author "this book is intended for the medical or dental student or practitioner who, although desirous of becoming an anaesthetist capable of dealing satisfactorily with any case that he may meet, does not wish to employ more expensive or complex apparatus than is necessary for his requirements." The intention of the author (the desirability of which may be questioned), has been achieved in this volume.

CLINICAL ELECTROCARDIOGRAPHY. By Sir Thomas Lewis, M.D., F.R.S., D.S.C., LL.D., F.R.C.P., C.B.E., Ed. 5, 120 pp., London, Shaw & Sons, Ltd., 1931.

The fifth edition of "Clinical Electrocardio-

graphy" presents the subject concisely, yet completely, as we have come to expect in the case of every book from the pen of Sir Thomas Lewis. Since the publication of the first edition of this book, a number of splendid American publications on the subject have appeared which are probably better adapted to the needs of general practitioners and students in this country than is this book. Those specializing in heart diseases will always gain knowledge from the writings of Sir Thomas Lewis.

HEMORRHOIDS, THE INJECTION TREATMENT AND PRURITUS ANI. By Lawrence Goldbacker, M.D. Ed. 2, revised. 199 pp., Phila., F. A. Davis Co., 1931.

The second edition, called for within one year, would indicate a demand for this book though it would seem that the subject is amply covered in chapters on the subject in textbooks on surgery and proctology.



## BOOKS RECEIVED

All books received by THE AMERICAN JOURNAL OF SURGERY are listed in this column as soon as possible after their receipt and this must be considered as adequate acknowledgment. Books that the Editor considers of special interest to our readers will be reviewed in a later issue.

ABDOMINAL PAIN. By John Morley. N. Y., Wm. Wood & Co., 1931.

ANATOMY AND PHYSIOLOGY OF CAPILLARIES. By August Krogh. New Haven, Yale Univ. Press, 1930.

AN INTRODUCTION TO PHARMACOLOGY AND THERAPEUTICS. By J. A. Gunn. N. Y., Oxford Univ. Press, 1931.

AUSSEREN ABDOMINAL-HERNIEN (Die). By Erich Bunn. Berlin, Urban & Schwarzenberg, 1931.

BAKTERIOLOGIE DER WURMFORTSATZENTUNG UND DER APPENDIKULAREN PERITONITIS (Die). By W. Lohr and L. Rassfeld. Leipzig, Georg Thieme, 1931.

BEITRAGE ZUR GERICHTLICHEN MEDIZIN. By Albin Habarda. Wien, Franz Deuticke, 1930.

CHININ IN DER ALLGEMEINPRAXIS. By Fritz Jolannesohn. Amsterdam, Bureau Tot Bevordering Van Het Kinine-Gebruik, 1930.

CHIRURGIE (Die). By M. Kirschner and O. Nordmann. Berlin, Urban & Schwarzenberg, 1930.

CHIRURGIA DEL DOLORE. By Ignazio Scalzone. Milano, Ulrico Hoepli, 1931.

COAL MINERS' NYSTAGMUS. By G. F. Haycraft, N. Y., Oxford Univ. Press, 1931.

COLLAPSOTHERAPIE DE LA TUBERCULOSE PULMONAIRE PNEUMOTHORAX ARTIFICIEL (La). By [Michel Leon Kindberg. Paris, Masson et Cie, 1931.

DIABETES. By Orlando H. Petty. Phila., F. A. Davis Co., 1931.

DISCOVERING OURSELVES. By Edward A. Strecker and Kenneth E. Appel. N. Y., Macmillan Co., 1931.

DISEASES OF THE TONGUE. By W. G. Speneer and S. Cade. Phila., P. Blakiston's Son & Co., Inc., 1931.

DOCTORS' WIVES. By Henry and Sylvia Lieferant. Boston, Little, Brown & Co., 1930.

EARLY THEORIES OF SEXUAL GENERATION. By F. J. Cole. N. Y., Oxford Univ. Press, 1930.

ETUDES NEUROLOGIQUES. By Georges Guillain and Th. Alajouanine. Paris, Masson et Cie, 1930.

FRACTURES AND THEIR COMPLICATIONS. By George Ewart Wilson. N. Y., Macmillan Co., 1931.

FRANKFURTER ZEITSCHRIFT FUR PATHOLOGIE. By Bernhard Fischer-Wasels. Munchen, J. F. Bergmann, 1930.

HALSTED, WILLIAM STEWART, SURGEON. By W. G. MacCallum. Baltimore, Johns Hopkins Press, 1930.

INTERNATIONAL MEDICAL ANNUAL. Edited by Carey F. Coombs and A. Rendle Short. N. Y., Wm. Wood & Co., 1931.

LETTERS OF DR. BETTERMAN. By Charles Elton Blanchard. Youngstown, Medical Success Press, 1931.

MODERN METHODS OF TREATMENT. By Logan Clendening. St. Louis, C. V. Mosby Co., 1931.

- OPERATIVE SURGERY. By Martin Kirschner. Phila., J. B. Lippincott Co., 1931.
- PHI RHO SIGMA FRATERNITY & UNIVERSITY OF MICHIGAN. By Jonathan and Donaldson Forman and Samuel Wright. Columbus, 1930.
- PHYSICAL BASIS OF PERSONALITY. By Charles R. Stockard. N. Y., W. W. Norton & Co., Inc., 1931.
- PHYSIOLOGY. By John F. Fulton. N. Y., Paul B. Hoeber, Inc., 1931.
- PRACTICAL X-RAY TREATMENT. By Arthur W. Erskine. St. Paul, Bruce Publishing Co., 1931.
- PRIMARY SYPHILIS IN THE FEMALE. By Thomas A. Davies. N. Y., Oxford Univ. Press, 1931.
- PROCEEDINGS OF THE ROYAL SOCIETY OF MEDICINE. By Hugh Thursfield and J. Swift Joly. London, Longman's Green & Co., Ltd., 1930.
- PROGRESSIVE MEDICINE. Edited by Hobart A. Hare and L. F. Appleman. Vols. III and IV, 1930; Vols. I and II, 1931. Phila., Lea & Febiger.
- RADIOLOGISCHE PRAKTIKA. Vol. XVII. Röntgendiagnostik der Gallenblase. By F. Eisler and G. Kopstein. Leipzig, Georg Thieme, 1931.
- RECENT ADVANCES IN RADIOLOGY. By Peter Kerley. Phila., P. Blakiston's Son & Co., Inc., 1931.
- ROENTGENOTHERAPIE (LA). By Iser Solomon. Paris, L'Expansion Scientifique, 1930.
- STRATEGY IN HANDLING PEOPLE. By Ewing T. Webb and John J. B. Morgan. Chicago, Boulton, Pierce & Co., 1931.
- SURGICAL CLINICS OF NORTH AMERICA. February, 1931. Phila., W. B. Saunders & Co., 1931.
- SURGICAL EMERGENCIES IN PRACTICE. By W. H. C. Romanis and Philip N. Mitchiner. N. Y., Wm. Wood & Co., 1931.
- SURGICAL NURSING. By Hugh Cabot. Phila., W. B. Saunders Co., 1931.
- SURGICAL PATHOLOGY OF THE DISEASES OF BONES. By Arthur E. Hertzler. Halstead, Kansas, 1930.
- TEXTBOOK OF PHYSICAL THERAPY. By William Benham Snow. N. Y., Scientific Authors Publishing Co., 1931.
- TRAITEMENT MEDICO-CHIRURGICAL DE L'OCCLUSION INTESTINALE AIGUE ET SUBAIGUE (LE). By Pierre Moiroud. Paris, Masson et Cie, 1931.
- TREATMENT OF INJURY BY THE GENERAL PRACTITIONER. By Clay R. Murray. N. Y., Harper & Bros., 1931.
- WUNDERHEILUNGEN VON EPIDAUROS (DIE). By Rudolf Herzog. Leipzig. Dieterich'sche Verlagsbuchhandlung, 1931.



# PRINCIPLES OF PREOPERATIVE & POSTOPERATIVE TREATMENT

BY

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# PRINCIPLES OF PREOPERATIVE & POSTOPERATIVE TREATMENT

## CHAPTER VIII

### ABDOMINAL DISTENTION AND "GAS PAINS"

#### I. ETIOLOGY OF DISTENTION AND "GAS PAINS"

A. GENERAL CONSIDERATIONS: Postoperative distention and "gas pains" are closely allied conditions. Abdominal distention represents the ostensible evidence of underlying intestinal distention which, in turn, results from ballooning of the wall of the gut by gas contained within its lumen. Moreover, as the intestine lies within a cavity, or potential cavity, i.e., the peritoneal cavity, the pressure within which is positive, ballooning of the wall of the intestine always indicates positive pressure of gas within its lumen.

Simple distention probably rarely, if ever, gives rise to a sensation acute enough to be dignified by the term "pain," though discomfort may be considerable. Acute pain invariably results, however, when ineffective peristalsis occurs in intestines, the seat of distention. The pain caused under these circumstances is "crampy" or "colicky" in nature, and depends upon the same mechanism of production as the pain of appendicitis, or of gall-bladder colic, i.e., it represents the ineffectual attempt of a hollow viscus to empty itself of its contents against pressure. Such pain is recurrent rather than constant; it undergoes exacerbations with every contraction and remissions with every relaxation of the intestinal musculature. The character of the sensations induced and the fact that the fundamental pathology consists of an accumulation of gas within the lumen of the intestines has given rise to the descriptive term "gas pains."

Abdominal operations are almost invariably followed by some degree of distention and "gas pains"; other operations

are occasionally but rarely thus complicated. Usually "gas pains" are mild, but sometimes become severe enough to cause considerable concern. Distention probably occurs most frequently and typically after operations on the biliary tract, less frequently after operations in the pelvis, and still less frequently following operations on the gastrointestinal tract. Distention is rare following operations for inguinal hernia.

It is a matter of common experience that "gas pains" do not ordinarily become established for at least twenty-four hours, usually from thirty-six to forty-eight hours, following operations. This "latent period" is dependent upon a number of factors which combine to depress intestinal tone and peristaltic activity in the early part of the postoperative period.

B. THE RÔLE OF "PHYSIOLOGICAL" OPERATIVE ILEUS: As every attendant at abdominal operations soon comes to appreciate, the opening of the peritoneal cavity *per se* in ordinary cases results in almost immediate cessation of intestinal movements; a functional or paralytic ileus is thereby produced. This statement is qualified by the phrase, "in ordinary cases," because as those who have had much experience with splanchnic or moderately high spinal analgesia will readily appreciate, paralysis of the splanchnic nerves tends to obviate this paralytic effect, so that peristalsis may not be completely abolished under such anesthesia. Intestines undergoing operative paralytic ileus under ordinary anesthetics do not soon regain their functional activity, even after the abdomen has been closed.

C. THE RÔLE OF INTRA-ABDOMINAL TRAUMA: The effect of mechanical manipulations is also to interfere with intestinal motility. This factor has been emphasized to a considerable extent in the past, and justly so. Protracted intestinal inertia much more frequently follows extensive intra-abdominal manipulations, especially when roughly or inexpertly performed, than occur under the opposite conditions. Cannon and Murphy<sup>1,2</sup> many years ago, showed that trauma is capable of interfering with the local muscular and nervous

mechanisms in the wall of the intestine and also that paralysis may result from indirect irritation through a reflex involving the splanchnic nerves.

Purgatives traumatize the intestine from within in very much the same manner as do mechanical manipulations from without. This in addition to being a matter of universal clinical experience, has been amply demonstrated experimentally by Alvarez and Taylor.<sup>34</sup>

D. THE ALLEGED RÔLE OF MORPHINE: The action of morphine on intestinal motility is ordinarily assumed to be one of inhibition of peristalsis and decrease of tone. Accordingly, it is usually believed that the preoperative and postoperative use of morphine subjects patients to the danger of developing intestinal stasis or actual ileus. Aversion to the use of morphine preoperatively and postoperatively is apparently, in part at least, a relic of a former misapprehension, born in the days when the pain caused by operative procedures was much more intense than at present, and morphine was required more frequently and in larger doses. During this period, in which excessive operative trauma was the rule, postoperative ileus occurred with distressing frequency, and the administration of the alkaloids of opium which had to be copious to relieve the pain came to be associated with the development of ileus in the minds of surgeons: a good example of the "non-sequitur" in surgical logic. No very good evidence, either clinical or experimental, has ever been produced to show that the use of morphine is of much etiological importance in the development of intestinal paralysis.

King and Church,<sup>5</sup> studying the effect of certain drugs on the motor activity of the muscularis mucosae of the dog, found that morphine was without effect either on tone or on rhythm, except when given in very large doses. Doses of less than 16 mg. were without effect, but doses larger than this occasionally acted as a depressant, although sometimes as much as 40 mg. showed no depressant effect at all. Nothnagle,<sup>6</sup> in 1882, used the etherized rabbit in testing the motility of

the small intestine, and by touching the intestinal wall with crystals of sodium chloride found that subcutaneous injections of morphine decreased the irritability of the gut. He concluded that moderate doses of morphine stimulate the splanchnic or inhibitory nerves to the intestines and that larger doses paralyze these nerves. He attributed the constipating effects of such doses of morphine, therefore, to splanchnic stimulation. Spitzer,<sup>7</sup> in 1891, repeated Nothnagle's experiment on non-etherized rabbits and was able to confirm the observations previously made, except that he observed that contractions did not always remain localized at the point of stimulation. He found also that the same effect was produced even though the mesentery was cut. Pal,<sup>8</sup> in 1900, using curarized dogs and recording the movements of the gut graphically by means of balloons introduced into the lumen of the intestine, found that intravenous injections of morphine and opium, both in small and large doses, invariably increased the tone of the gut and stimulated rhythmic contractions. This occurred even in cases in which the nerve supply to the loop of intestine had been divided. He believed that the effect of morphine depended upon stimulation of the ganglia in the wall of the intestines. Magnus,<sup>9</sup> in 1906, repeated Nothnagle's original experiment on etherized rabbits, but was not able to demonstrate any decreased excitability due to the injection of moderate doses of morphine. Larger doses of morphine, however, he found frequently increased the irritability of the gut and often led to the production of spontaneous contraction even in the absence of stimulation. In 1908, Magnus<sup>10</sup> attempted to determine the pharmacological action of morphine on the small intestine by the fluoroscopic method. He showed that constipating doses of morphine and opium had no marked effect on the small intestine. The stomach did, however, show delay in emptying, apparently due to vigorous contractions in the region of the pyloric antrum. He believed, therefore, that constipating effects of morphine are due to delay in the emptying time of the stomach. He confirmed his observations on dogs. Rodari,<sup>11</sup>

observing the exposed intestine in anesthetized rabbits, found that the injection of opium produced peristaltic waves which persisted from one to two minutes and were followed by a condition of contracture. Schapiro,<sup>12</sup> in 1913, observed the movements of the alimentary canal in human subjects after injections of morphine and opium. He noted variable effects. Usually the contraction of the small intestine after passage of food through this part of the gut was not affected. Sometimes the contraction and tone were increased. A few cases showed delay in emptying of the small intestine which seemed to occur at the ileocecal valve. In about half of his cases the stomach was found to empty slowly. Occasionally, however, there was an acceleration of the emptying time. He attributed the constipating effect of morphine to loss of the "defecation reflex." Uhlman and Abelin,<sup>13</sup> in 1920, observed the effect of opium on the intestine of etherized rabbits and guinea pigs. They found that although small doses of opium decreased the tone of the intestine and inhibited peristalsis, larger doses caused distinct increases both of tone and contraction. Plant and Miller,<sup>14</sup> using dogs in which a Thiry-Vella fistula had been made and in which observations were recorded by mechanical means after complete recovery of the animals from the operative procedure had occurred, found that the effect of morphine on the muscular activity of the small intestine was very constant. There was always a decided increase in tone which sometimes amounted to a condition of spasticity. Peristalsis occurred after a period of initial inhibition, and the peristaltic waves showed a distinct increase in frequency. They were often higher and broader than before. Small rhythmic waves, which were noted and were interpreted as being segmentation waves, were usually increased in amplitude, but were not increased in number. Dogs observed over a period of weeks, during which time there were regular daily injections of from .1 to 5 mg. of morphine per kilogram of body weight, showed no noticeable change in the number or character of the stools per twenty-four hours. These authors also studied the

effect of morphine on the small bowel of a man who presented a fistula in the ileum. The results were the same as those in the dog. There was an increase in tone accompanied by an increase in amplitude of the waves and an increased rate of peristalsis. Various other alkaloids of morphine, viz., heroin, codeine, papaverine, narceine, and narcotine, were found to produce effects similar to those produced by morphine but in much less degree. Plant and Miller<sup>14</sup> reported the effect of repeated small doses of morphine. In these experiments they also used the Thiry-Vella fistula and the graphic method of recording peristaltic movement. Kymographic records taken on the tenth, twenty-ninth, fiftieth, and seventy-first days of the experiment showed typical reactions to morphine consisting of decided increase in tone, amplitude, and frequency of peristaltic waves.

In view of this experimental evidence there would seem to be very little reason for apprehension with respect to the development of either distention or postoperative ileus as the result of the administration of morphine or indeed any of the other alkaloids of opium as ordinarily practiced in the treatment of preoperative and postoperative cases. Clinical observations would seem to coincide with the theoretical and experimental considerations. Certainly clinical cases of ileus definitely ascribable to the use of morphine do not find their way into the literature, and those who fear to use morphine because of its supposedly baneful effect on intestinal movement have apparently been victimized by a tradition passed on from former days.

E. THE NATURE AND SOURCE OF THE GAS OF INTESTINAL DISTENTION: Gas pains, as previously mentioned, represent ineffectual attempts of the intestine to empty itself against pressure. This ineffectuality of peristaltic activity is presumably partly due to the nature of the substance contained within the intestinal lumen and partly to the fact that the same factors which are instrumental in producing the initial quiescence also disturb the normal muscular and nervous

mechanism of intestinal motility to such an extent that motor responses of the intestinal tract when first resumed tend to be disorderly and valueless.

Mechanical trauma, the action of cathartics, and possibly to some extent, proctoclysis undoubtedly combine in predisposing to such disorderliness in resumption of function, and accordingly gas pains tend to be maximal when such factors are maximal, and minimal when such factors are minimal.

In considering deranged motility as of etiological importance in the development of distention and gas pains, however, sight must not be lost of the fact that fundamentally deranged motility is a predisposing rather than an exciting cause of the complications under discussion; the equally important and correlative factor is the gas content of the intestinal tract. Gas, because of its peculiar physical properties, is expelled by peristaltic activity with much greater difficulty than either liquids or solids, and consequently distention, once established, tends to be persistent.

In conditions of health small amounts of gas are present in the intestine. The amount of such gas is insufficient to cause annoyance, and ordinarily a person is, therefore, unaware of its presence. The origin of intestinal gas is threefold: (1) the decomposition of foodstuffs, (2) diffusion of gas from the blood stream, and (3) swallowed atmospheric air.

1. *Decomposition of Foodstuffs*: There is evidence for believing that considerable quantities of gas are formed during the normal process of digestion. It occurs primarily in the form of carbon dioxide and is apparently formed as follows: (a) By the action of the acid gastric contents on the carbonates secreted in the alkaline biliary and pancreatic secretions: von Bunge<sup>15</sup> has estimated the amount of gas thus produced at 6 l. daily. (b) By the action of bacteria on sugars in the lower portion of the small intestine: Apparently in health the amount of carbon dioxide thus formed is negligible, for virtually all of the starches and sugars are reduced by the action of digestive enzymes to monosaccharids in the upper portion of the small

intestine and these monosaccharids are completely absorbed, leaving no residue. (c) By the action of bacteria on any residue of cellulose which remains after digestion is complete: In man no digestive enzyme capable of splitting cellulose is secreted in the digestive juices. The end-products of cellulose decomposition by bacteria are carbon dioxide and fatty acids; the latter doubtless become neutralized by alkaline carbonates secreted in the proximal portion of the colon with the production of still more carbon dioxide.

The other gases present in the normal intestines occur only in traces. These gases are marsh gas, which has the formula  $\text{CH}_4$ , hydrogen, indole, skatol, hydrogen sulphide, and ammonia. Except for marsh gas and hydrogen, these gases must be derived entirely from the putrefaction of proteins.

Fries<sup>16</sup> has estimated that the volume of gas discharged daily through the rectum in health amounts to about 1 l. Inasmuch as much more gas than this is formed, the conclusion is obvious that a large percentage of the gas must be excreted through other channels. Tacke,<sup>17</sup> working with rabbits, found that from ten to twenty times as much intestinal gas was eliminated from the body by the lung as by direct expression from the lower bowel.

Inasmuch as patients subjected to ordinary operative procedures come to the operating table with a relatively empty gastrointestinal tract, and because at the time of the preoperative procedure such patients show no evidence of flatulence or distention, the occurrence of distention postoperatively in such cases can scarcely be attributed to any of these factors. Furthermore, as far as carbon dioxide itself is concerned the production of large quantities of this gas could scarcely lead to any undue degree of distention under ordinary circumstances, because carbon dioxide is very rapidly absorbed by the blood and exhaled from the lungs. Experimentally, Kato<sup>18</sup> showed that when carbon dioxide is artificially introduced into the small intestine at least 90 per cent of the gas is rapidly absorbed. Only in cases in which the venous drainage



from the small bowel was interrupted could carbon dioxide remain in considerable amounts. Thus he showed that if the portal vein was ligated only 40 per cent of the gas was removed from the intestinal lumen instead of 90 per cent within a given unit of time. Ligation of the portal vein, however, is, of course, inconsistent with life, as is any considerable interference with the venous return through the portal vein. Kantor and Marks<sup>19</sup> believe that a certain amount of flatulence may be caused by defective splanchnic circulation. They present evidence to show that flatulence is frequently associated with hypertension and is a common occurrence in arteriosclerosis, particularly in mesenteric arteriosclerosis. It is possible that damage to the intestinal mucosa, as by inflammation or operative trauma, accompanied by overproduction of mucus, may cause diminished absorption of carbon dioxide from the intestinal lumen. Schoen,<sup>20</sup> however, showed experimentally that when he poured corrosive fluids into the small intestine no interference with gas absorption occurred.

In cases in which residues from the digestion of vegetables rich in cellulose remain in the large intestine at the time of operation considerable gas might be formed by the action of bacteria on the cellulose, although clinical symptoms would hardly result because there is every reason to believe that this gas would be rapidly absorbed, consisting as it does of carbon dioxide. Such vegetables as cabbage in the form of cooked cabbage or sauerkraut and slaw, cauliflower, Brussels sprouts, carrots, turnips, beets, and the leguminous vegetables, peas and beans, contain considerable amounts of cellulose in the form of tough membranes which enclose starch granules. Patients who immediately prior to operation had eaten quantities of such vegetables and in whom intestinal evacuation had not subsequently occurred would be particularly liable to distention from this source. However, such articles of diet are not ordinarily supplied to patients in the days just preceding abdominal operations and can hardly play any considerable rôle in the development of ordinary postoperative

distention. Actually such analyses of the gas of postoperative distention as have been made indicate that carbon dioxide plays a very unimportant rôle in the etiology.

2. *Diffusion of Gas from the Blood Stream:* As McIver, Redfield, and Benedict<sup>22</sup> have shown nitrogen itself may be derived from the blood by a process of diffusion. These observers found that when either oxygen or nitrogen was injected into isolated loops of the small intestine the gas in the intestine underwent a progressive change in composition, in accordance with which the oxygen or hydrogen disappeared, and its place was taken by nitrogen. Nitrogen itself, of course, occurs in the blood stream in simple solutions under a partial pressure of about four-fifths of an atmosphere. Oxygen and carbon dioxide, however, occur in the blood stream in chemical combination. Thus the nitrogen is free to leave the blood stream and replace other gases in the intestinal lumen when pressure relationships are favorable; whereas, in order for oxygen or carbon dioxide to leave the blood stream, not only must pressure relationship be upset, but also conditions must be produced favorable to the chemical liberation of these gases.

3. *Swallowed Atmospheric Air:* The most recent analyses of gas from postoperative cases as performed by McIver and his associates<sup>22</sup> have shown that intestinal gas obtained from postoperative cases presents a composition closely resembling atmospheric air. It is composed essentially of nitrogen, four parts, and oxygen, one part; only small amounts of carbon dioxide and traces of other gases, such as methane and hydrogen sulphide, were found.

E. B. Benedict<sup>22</sup> has determined experimentally, that all of these gases pass between the intestinal lumen and the blood stream in accordance with the well understood physical laws of the diffusion of gases, a condition of equilibrium existing only when the partial pressure of a given gas within the lumen of the intestine is equal to the mean pressure of the gas in the blood stream. Normally, the amount of gas in the intestinal lumen is minimal for the reason that gases diffuse into the blood

stream about as rapidly as they are formed. The presence of distention, however, is an indication that there exists a process of unstable equilibrium and that accumulation is more rapid than diffusion.

The rates of diffusion for various gases found characteristically in distention have been experimentally determined by introducing measured amounts of these gases into closed loops of intestine in cats and subsequently measuring accurately the amount of absorption which occurs per unit of time. The number of cubic centimeters of various gases absorbed from a loop of intestine 25 in. long per hour are represented essentially as follows:<sup>22</sup>

CO <sub>2</sub>	H <sub>2</sub> S	O <sub>2</sub>	H <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub>
160	69	14	7	2	1

As previously stated, the percentage composition of the gas of intestinal distention is very nearly that of atmospheric air as far as the proportion between its main constituents, nitrogen and oxygen, are concerned; the other constituent gases occur in somewhat greater proportions than are found in atmospheric air, but the absolute amount of such gases is small.

These considerations offer rather convincing evidence (1) that the gas of intestinal distention is derived mainly from the swallowing of atmospheric air, (2) that the process of eliminating the gas of distention is largely one of diffusion rather than actual expulsion, (3) that intestinal putrefaction upon which must depend the presence of such gases as hydrogen sulphide and methane is to be reckoned with only as a minor factor in the production of distention, and (4) that diffusion of gases from the blood stream into the lumen of the intestine is a negligible factor in the formation of distention because diffusion acts as a mechanism tending toward equilibrium rather than the reverse.

The importance of air swallowing in the production of distention and gas pains is clinically attested by the frequency with which distention follows the unskilful induction of general anesthesia, during which the patient strains, gags, swallows,

and vomits, every forceful expulsive action of the patient being followed by a correspondingly forceful impulsive reaction. Considerable air swallowing probably also occurs during the period of reaction from general anesthetics. Preliminary gulping and swallowing usually precedes vomiting or attempts at vomiting.

The preceding discussion is believed to indicate the essential factors concerned in the development of distention and gas pains.

The causative factors in distention are mainly two: (1) air swallowing and (2) relaxation of the intestinal musculature due to adynamic ileus. To these must be added the less important contributing factors, (3) intestinal putrefaction and (4) possibly some stagnation of the splanchnic circulation due partly to lack of motility and partly to traumatic shock, a stagnation which interferes with the normal diffusion of gases from the intestinal lumen. The predisposing factors in the production of "gas pains" are (1) interference with normal intestinal motility in accordance with which intestinal contractions become disorderly and inefficient, and (2) the nature of the contents of the intestinal tract which, being gaseous, cannot easily be propelled and expelled. On the basis of these considerations the rational treatment of "gas pains" must be founded.

## II. PROPHYLACTIC TREATMENT

Splanchnic and spinal anesthesia tend to be followed by a minimum of distention and gas pains. Splanchnic block, which is common to both these forms of analgesia prevents the delivery of inhibitory impulses to much of the intestinal musculature. The result is that paralysis of the intestine is reduced to a minimum. The tonicity of the intestinal wall also being largely preserved and intestinal movements tending to persist, air does not easily find its way into the digestive tract and such air as does become imprisoned thus tends to be passed on and expelled. *Per contra*, under conditions of general anesthesia,

the intestinal wall tends to become maximally paralyzed, and, in addition, the nature of the process of induction and reaction from anesthesia is such that air swallowing is facilitated. From the point of view of distention and gas pains alone, therefore, spinal and splanchnic anesthesia presents obvious advantages over inhalation anesthesia.

General inhalation anesthesia, however, presents certain general advantages which are usually accepted as outweighing such minor disadvantages as the one under discussion and general anesthesia, therefore, rightly remains the anesthesia of choice in most operative procedures. In the use of such anesthesia, the prophylaxis of distention and gas pains should be carefully considered. Particular attention should be paid to the manner of induction; the patient who "takes the anesthesia" poorly may be expected to develop the complications under discussion in maximal degree.

As far as intestinal trauma is concerned the particular indications to be observed are the avoidance of unnecessary, unskillful, and inconsiderate intra-abdominal manipulations, and the avoidance of preoperative catharsis.

The administration of proctoclysis, though theoretically possibly contraindicated from the point of view of the particular complications under discussion, serves such obviously beneficent functions otherwise that a slight tendency to undesirable side actions constitutes no valid objection to its use.

### III. ACTIVE TREATMENT

Granting that the mechanism of distention and gas pains has been accurately stated, it will readily be seen that these complications are fundamentally self-limited conditions. Postoperative intestinal accumulations of gas are dissipated primarily not by mechanical evacuation or expulsion, but by absorption into the blood stream. The rate of absorption cannot readily be hastened artificially because it depends upon pressure relationships and the percentage composition of the contained gas, factors which for the most part cannot be

controlled. Fundamentally time alone is capable of dealing with the situation once distention has become established.

Much difficulty arises when these facts are not appreciated, because the tendency then is to attempt to increase peristalsis in an effort to favor mechanical expulsion of the gas; enemas are given and drugs are administered with the idea of whipping the sluggish intestine into action. The results of such therapy are not only theoretically irrational but clinically disappointing. Such measures only exaggerate muscular incoordination and delay resolution.

A. THE USE OF ENEMATA: Enemata produce their characteristic action by irritating the mucosa of the rectum, sigmoid, and colon, thereby producing violent contractions of those structures; probably also to a certain degree by causing sympathetic reflex contractions of the small intestine. The gas of distention is not confined to the large intestine, and even were this the case the pressure of peristalsis would probably not be needed to evacuate it provided only that the resistance of the rectal sphincters was relieved, as can so readily be accomplished by the insertion of a rectal tube. When enemas are given an amount of gas is expelled similar to that recoverable by the use of a rectal tube alone, and not infrequently a period of symptomatic relief follows; but if the abdomen be carefully examined subsequently little actual decrease in girth will be noted at the time, and within a very few hours distention frequently will be found to have increased, and all the patient's symptoms will have undergone a distinct exacerbation. The explanation is apparent. The initial relief results from expulsion of colonic gas due, not to stimulation of peristalsis, but rather to simple relief of pressure incident to the mechanical opening of the rectal sphincters. The exacerbation represents a reactionary goading of peristaltic action in the small intestine which is purposeless and valueless partly because the movements are not properly coordinated and partly because of the inherent difficulty of expelling gas by the mechanism of peristalsis, even in the presence of orderly

movements. If now another enema be given the patient the cycle of events is repeated, and the latter condition of the patient becomes progressively worse than the first, because frequent peristalsis easily leads to motor exhaustion.

B. THE USE OF STIMULATING DRUGS: A number of drugs have been devised and used at various times for their supposed stimulating effect on intestinal movements. Of these probably the most familiar and widely used are eserine and pituitrin.

1. *Eserine*, or *physostigmine*, is the active principle of the calabar bean. For nearly fifty years this drug has been used clinically for its stimulating action on intestinal motility. Fröhner<sup>23</sup> states that as early as 1882 Dickerhoff made use of the drug in the practice of veterinary surgery for the relief of obstruction in animals. Westermann, however, in 1867 reported the occurrence of tetanic contraction of the intestinal wall in cats, rabbits, and dogs, following the administration of a 2.5 per cent glycerin solution of the alcoholic extract of the calabar bean.

Alvarez,<sup>24</sup> Cross,<sup>25</sup> and Baur<sup>26</sup> have examined the effects of eserine on isolated strips of smooth muscle from the intestinal tract of experimental animals. They have found generally that the action of eserine is to increase the tone of the musculature and to produce increases in the amplitude of intestinal contraction. The action of the drug seems to depend upon either a direct stimulation of the motor end plates of smooth muscle or the plexuses contained within the intestinal wall, or possibly the drug increases the irritability of these structures to motor stimuli. LeHeux<sup>27</sup> and Brunner and Weigand<sup>28</sup> were able to observe increases in intestinal movement under the fluoroscopic screen following the exhibition of physostigmine. Oppenheim,<sup>29</sup> Bauer,<sup>30</sup> and also Cannon and Murphy<sup>1</sup> observed active stimulation of the motor mechanism of the intestines at laparotomy in experimental animals. Ross,<sup>31</sup> McIntosh and Owings,<sup>32</sup> and Ochsner, Gage, and Cutting<sup>33</sup> recorded the effect of eserine on the intestinal canal of intact animals graphically. The results obtained by these investi-

gators in general confirm the observations of previous workers; increases in intestinal tone and movement were noted.

Among the early clinicians to use eserine were Hiller,<sup>34</sup> Subbotin,<sup>35</sup> and Schaefer,<sup>36</sup> who used the drug to combat flatulence and atony of the intestine. During the early years of the present century clinicians were in the habit of attempting to induce active movements of the bowel within a relatively few hours postoperatively. A number of authors during this period used eserine salicylate both prophylactically and curatively with apparent success (Noorden, Packard, Arndt, Vogel, Craig, Goth, Moeninghoff). In more recent years eserine has been used with success in the treatment of intestinal atony by Martin and Weiss,<sup>37</sup> Vogel,<sup>38</sup> Bartlett,<sup>39</sup> and Cross.<sup>25</sup> Martzloff,<sup>40</sup> however, working in the Johns Hopkins Hospital, has made an unfavorable report on the basis of a study of the use of a combination of eserine and strychnine prophylactically in 162 cases subjected to major abdominal operations under ether anesthesia. His investigation was well controlled, and he found that in patients receiving this prophylactic treatment for distention and gas pain, emesis, and distention occurred more frequently in treated cases than in untreated ones and that voluntary micturition was reestablished earlier in the non-treated cases than in the treated cases. He concludes that no benefits may be expected to result from the preoperative use of eserine and strychnine in the prophylactic treatment of these conditions. In criticism of the work of Martzloff<sup>40</sup> it has been contended that too small doses of the drug were used, and furthermore that the drug was used prophylactically and not curatively.

Because of the fact that almost all of the reports, both experimental and clinical, on the use of eserine in the stimulation of intestinal movement have been favorable, there seems to be little room for doubt that eserine may be of value in any condition in which stimulation of intestinal motility is indicated; but there still seems to be some doubt as to whether eserine as usually administered to patients is actually of real



value in combating the more severe degrees of intestinal atony. Certainly the results obtained in experimental animals by the injection of eserine are not quite so pronounced or striking as certain of the clinical and experimental observations would lead one to suppose. A representative tracing of the effect obtained by the injection of  $\frac{1}{50}$  grain of eserine sulphate into the dog is reproduced (Fig. 42). Although a noticeable increase in tone follows the injection of the drug, the increase in intestinal movement which follows is not particularly marked, and it seems rather doubtful whether so slight an augmentation in tone and motility would be capable of producing any very startling effect in the actual expulsion of material from the intestinal tract. Furthermore, certain investigators, notably Moennighoff,<sup>41</sup> have observed satisfactory movements of the bowel only in case the drug treatment was supplemented by the use of an enema. Moennighoff believes, for this reason, that physostigmine acts only on the small bowel, but unless this can be demonstrated, it seems more rational to believe that the action of eserine is perhaps the same throughout the entire intestinal tract, as apparently shown by Bauer and others, and the effect of enemata is additive and supplemental. This view of the relative inefficiency of eserine is held by many of those who have worked clinically with physostigmine, notably Ross and Martzloff.

2. *Pituitrin, Pitocin*: Pituitrin is regarded by most practitioners as a drug of especial value in the stimulation of intestinal motility. Oliver and Schäfer<sup>42</sup> were able to show that extracts of the pituitary gland are capable, under certain circumstances at least, of stimulating contraction in smooth muscle and thus paved the way for the clinical use of the drug in the stimulation of intestinal movement. Blair Bell<sup>43</sup> and his pupils were among the first to make use of pituitary extract clinically for its motor effect upon the intestine. Blair Bell found that defecation occurred following the use of these extracts and believed that intestinal motility and tone were increased by pituitrin. He found, however, that frequently

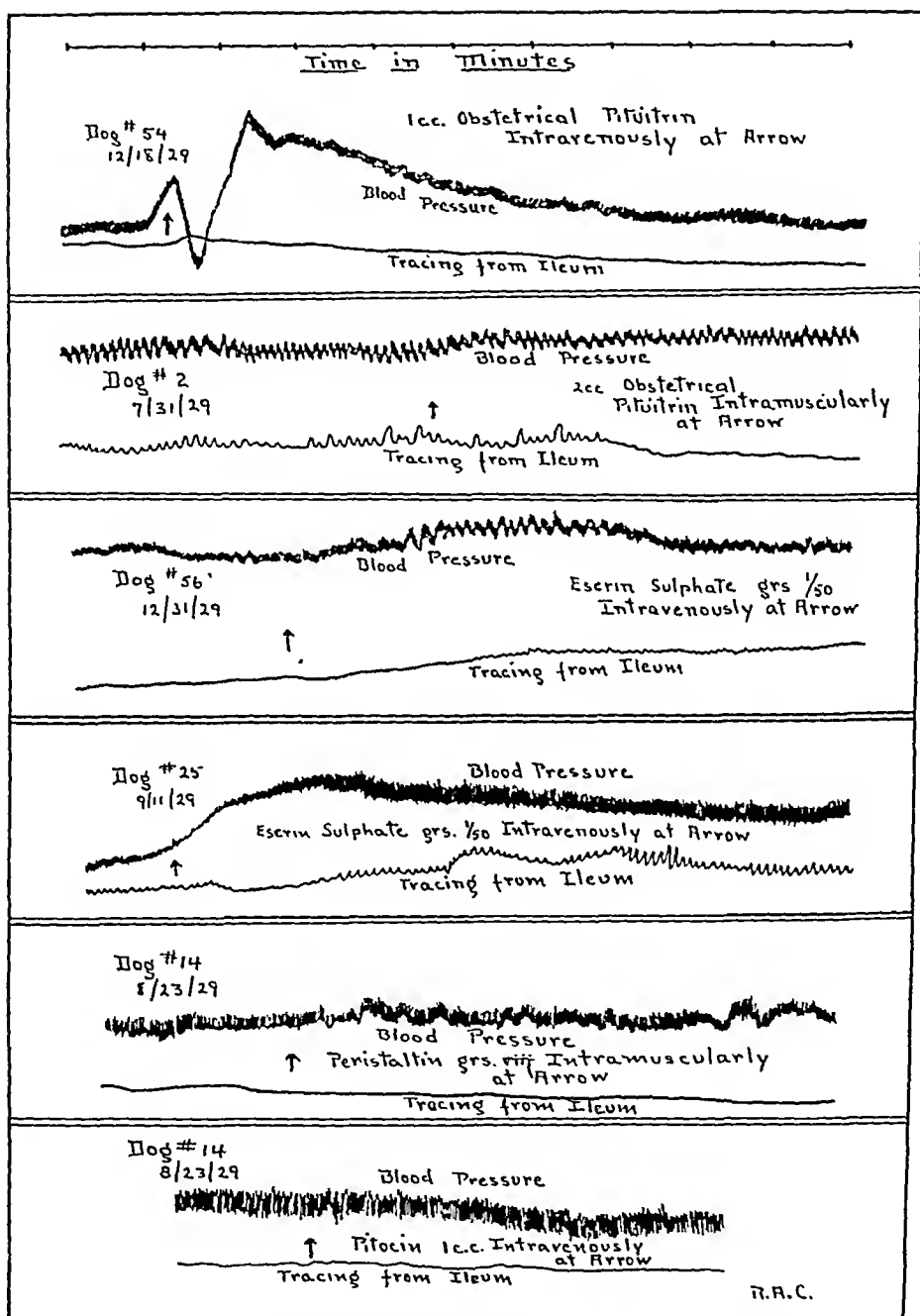


FIG. 42. Kymographic tracings, greatly reduced, of motor action of some of drugs commonly used for alleged stimulating effect on intestinal musculature. At top of page [580]

a period of relaxation preceded the institution of a strong contraction.

The experimental investigation of the action of pituitrin on the intestinal musculature has yielded some very interesting but inconclusive evidence. Certain investigators have attributed to pituitrin a stimulating action, whereas others have found characteristically the exact reverse. Among those who have found pituitrin stimulating to the intestinal musculature are Fodera and Pittau,<sup>44</sup> Guggenheim,<sup>45</sup> Young,<sup>46</sup> Roth,<sup>47</sup> and Dixon.<sup>48</sup> King and Church<sup>5</sup> also found a stimulating action on isolated intestinal muscle, but they were never able to obtain this effect by injecting pituitrin into living animals. Cross<sup>25</sup> was able to produce slight increases in tone in the musculature of pieces of human appendix removed at operation. Kaufmann<sup>49</sup> found that pituitrin caused a definite stimulation of the ileum in both cats and rabbits, but that no such effect was encountered either on the duodenum or jejunum. Young<sup>46</sup> found that although the watery solution of pituitary substance was effective in promoting intestinal movement, the alcoholic extract was not. Dixon<sup>48</sup>

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is a time-marker tracing indicating minutes; with this all of the tracings subsequently reproduced can be compared since all tracings have been reduced to scale. Tracings recorded in each of transverse panels were similarly obtained and are therefore directly comparable, blood-pressure tracing in each case being a manometer record taken from left carotid artery, and tracing from ileum being recorded by means of thin rubber balloon placed within lumen of gut and connecting with recording tambour by means of rubber tubing. Dogs were used as experimental animals and were manipulated under barbital anesthesia.

Two upper panels represent effect of pituitrin; note inconstant effect of drug on blood-pressure, decrease in tone of gut after injection of substance in both cases, and definite inhibition of movement in second case. These are usual effects of pituitrin; *very rarely* pituitrin has been seen to increase tone and movement slightly.

The succeeding two panels represent characteristic effect of eserine. Note consistent slight increase in blood pressure following injection of drug and general tendency toward increase in both tone and motility of gut. Stimulatory action of eserine is rather constant but relatively feeble.

In two lower panels effects of peristaltin and pitocin have been reproduced; these drugs are apparently inert both with respect to blood-pressure and intestinal movement.

Tracings obtained after injection of choline and acetylcholin show no effect on gut although both drugs depress blood-pressure; tracings illustrating action of these drugs were omitted in order to avoid monotony.

found that, even though pituitary extract caused an increase in the movements of the small intestine, it produced the opposite effect on the large gut. Brunner and Weigand<sup>28</sup> apparently confirmed this observation under the fluoroscope, using cats.

Among those who have noted the production of relaxation rather than contraction following the administration of pituitrin may be mentioned Bayer and Peter,<sup>50</sup> who found that contractions occur only occasionally and always after a period of relaxation, Shamoff,<sup>51</sup> who noted relaxation and inhibition of rhythmic contraction, and Hoskins,<sup>52</sup> Pancoast and Hopkins,<sup>53</sup> Atwell and Marinus,<sup>54</sup> and MacDonald,<sup>55</sup> who believe that extracts of pituitary gland vary greatly in their content of intestinal stimulant and that the pituitary gland is not particularly richer than several other tissues. McIntosh and Owings<sup>32</sup> have noted slight relaxation or no change at all following pituitary injections in both normal and obstructed loops of bowel. Roth<sup>47</sup> believes that when the stimulating effect of pituitary extract is not seen, the explanation is to be found in contamination of the preparation with chloretone. Degcner<sup>56</sup> has likewise seen a characteristic inhibitory action of the extract of the posterior lobe of the pituitary. Voegtlin,<sup>57</sup> using rats as experimental animals, found inhibition of both tone and pendular movement even with a carefully prepared chloretone-free and histamine-free preparation of pituitary extract. It should be emphasized furthermore that most of the favorable reports on the stimulating action of pituitrin have been made not by experimental but by clinical investigators, Bidwell,<sup>58</sup> Duffcy,<sup>59</sup> Mayer,<sup>60</sup> Vogt,<sup>61</sup> and Krinsky.<sup>62</sup>

Certainly the ordinary effect produced by commercial pituitrin on experimental animals is one of loss of tone and diminution in the amplitude of contraction. A characteristic tracing of such an effect is reproduced herewith. It should, however, be remarked that in occasional instances the administration of pituitrin is followed by the opposite effect, viz., an increase in tone and an increase in the amplitude of intestinal contraction. This exceptional effect has apparently

been sometimes observed clinically and has been responsible for the extravagant claims of clinicians.

*Pitocin:* Apparently because of a recognition of the generally unsatisfactory character of pituitrin itself a special extract of pituitary gland called "pitocin" has been placed on the market. This drug is supposed to exert a universally stimulating effect on the intestinal musculature, and, therefore, should be preferable to pituitrin. Experimental investigations conducted on this drug by Ochsner, Gage, and Cutting<sup>33</sup> apparently showed that pitocin is quite worthless as an intestinal stimulant. Not only have increases in intestinal tone and movement been conspicuous by their absence when "pitocin" has been used, but also the occasional stimulatory effect shown by pituitrin has never been seen when this drug has been used. For this reason "pitocin" would seem to be of even less value than pituitrin, although it must also be admitted in fairness to "pitocin" that it does not produce the depression of tone and cessation of intestinal movement which is characteristic of pituitrin. A representative effect of "pitocin" administration is herewith reproduced.

3. *Other Drugs, Choline and Acetyl Choline, Peristaltin:*  
*Choline and Acetyl Choline:* In 1912 Weiland<sup>63</sup> made the accidental discovery that when isolated strips of intestine were allowed to contract for considerable periods of time in Ringer's solution, the Ringer's solution could thereafter be shown to exhibit a stimulating effect when brought into contact with fresh pieces of intestine. The substance responsible for this reaction was isolated by LeHeux<sup>64</sup> in Magnus's laboratory at Utrecht and was called "choline." Magnus thought that this substance was the hormone responsible for the regulation of intestinal motor activity, because he found that it was without action on the uterus or the heart and invariably acted as a stimulant to the intestinal musculature. Magnus,<sup>65</sup> in 1925, stated that the isolated small intestine of the rabbit gives off 3 mg. of choline from its mucosal surface per hour. He believes that this substance activates the plexus of Auerbach, for, if

this plexus be removed from isolated muscular strips, the tolerance for choline is much increased. The action of choline as an intestinal stimulant has been corroborated by a number of investigators, notably Grossmann,<sup>66</sup> Guggenheim and Loeffler,<sup>67</sup> and Dale.<sup>68</sup>

Apparently certain organic acid derivatives of choline are more efficient in the stimulation of intestinal movement than is choline itself. The effect of the acetic acid derivative, acetyl choline, has been stated to be a thousand times as intense as that of choline itself (Wolfe and Canney<sup>69</sup>). LeHeux,<sup>70</sup> in 1921, experimented on the choline esters of succinic, pyruvic, butyric, isovaleric, and benzoic acids and found that all of these esters, with the single exception of the succinic acid ester, were more powerful than choline itself. Choline and acetyl choline have been used with some success clinically, especially by German practitioners, but apparently these drugs do not possess the salutary clinical results which might be expected from a consideration of many of the experimental investigations. Indeed, Carlson, Smith and Gibbens,<sup>71</sup> and Ochsner, Gage, and Cutting<sup>33</sup> have produced experimental evidence to show that the action of choline and its esters is neither constant nor conspicuous.

*Peristaltin*: Peristaltin, a preparation of the soluble glucoside of cascara sagrada suitable for hypodermic injection, is supposed to have a specific stimulatory action on the intestinal musculature. The drug has as yet been subjected to little experimental investigation, but Ochsner, Gage, and Cutting<sup>33</sup> have presented experimental evidence, indicating that this substance is of relatively little value. No significant effects have been seen on the intestine of intact animals following its intravenous injection. A tracing showing the typical action of the drug is herewith reproduced (Fig. 42).

A consideration of the foregoing rather lengthy discussion brings the value of the drug therapy of distension and gas pains into very serious question not only from the point of view of misapprehension as to the end to be achieved, but also

with respect to the action of the aforementioned agents in accomplishing that for which they were designed. All in all, the drug therapy of intestinal distention, in general, and gas pains in particular stands on very precarious ground. This is as true clinically as it is theoretically. Although brilliant results may occasionally be encountered as the result of the use of drugs, every clinician of experience knows that the usual effects are very disappointing.

Therefore, as the expulsion of gas in postoperative intestinal distention cannot be well induced either by unaided intestinal peristalsis or by reinforcement of the intestinal movements by physical or pharmacological means, the treatment of distention and gas pains is largely expectant. This does not at all mean that nothing can be done to make the patient's suffering from distention or gas pains more comfortable, but rather that, whatever is done, time alone can solve the problem satisfactorily. Hence, instead of attempting to induce intestinal contractions, which are painful and inefficient, the opposite result should be sought, and means should be employed to induce and maintain intestinal quiescence. This, and this alone, will ensure for the patient the maximum amount of comfort because it will provide the greatest cubical capacity for the gas contained within the intestines and consequently will reduce intra-intestinal pressure to a minimum.

C. THE USE OF MORPHINE: Morphine may be given without compunction for the relief of gas pains if necessary, but gas pains characteristically occur at a time when the administration of morphine is not particularly desirable, for usually the acute postoperative traumatic or incisional pain has largely disappeared before the onset of gas pains, and the administration of morphine has therefore been discontinued by the medical attendant, perhaps with a feeling of relief because of a conviction that too many doses have already been required. The resumption of morphine medication may occasionally be required in the severe cases, but much relief can be given by using simple physical measures.

D. THE RELIEF OF MECHANICAL TENSION DUE TO TIGHT BANDAGING: As stated previously in connection with the general discussion of postoperative care, a moderate degree of disten-

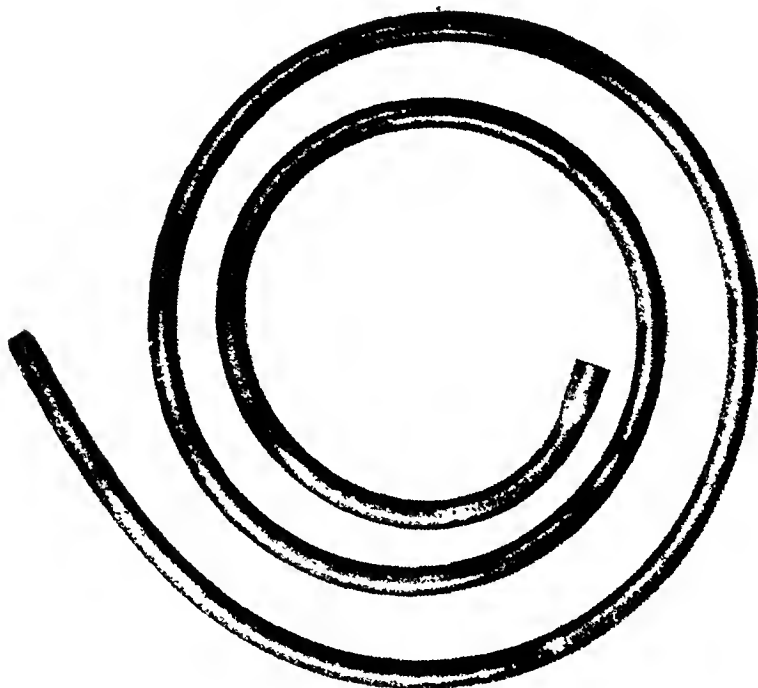


FIG. 43. Usual type of soft rubber rectal tube.

tion may be greatly accentuated by the presence of a tight restraining abdominal dressing. Some surgeons habitually make use of voluminous dressings and wide adhesive plaster straps extending from flank to flank and sometimes almost from symphysis pubis to the ensiform process of the sternum. Occasionally such a dressing may be necessary, but usually it serves no useful function and causes the patient much discomfort. If such a dressing has been used, and marked abdominal distention occurs the thoughtful medical attendant will carefully remove the unnecessary restraining strips of plaster



or will slit them in such a manner as to relieve tension as much as possible, or at least as much as he deems safe.

E. THE USE OF STOMACH AND RECTAL TUBES: If this simple

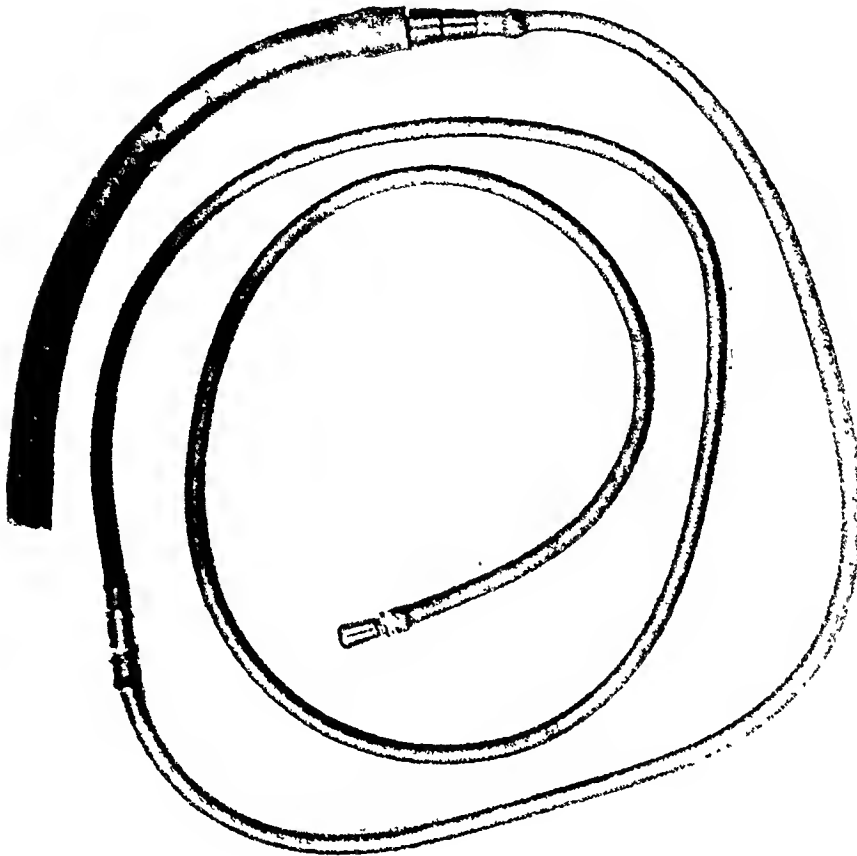


FIG. 44. Gastric or duodenal tube of the Jutte type. Tube proper consists of relatively thin rubber, and its caliber is relatively small; metal tip is tied into the end; tube is perforated for a short distance proximal to tip by a series of small holes, too small to be well seen in illustration. Jutte tube differs from Levin tube (Fig. 45) in thinness of wall, small size of perforations, and metal tip.

procedure does not make the patient reasonably comfortable the surgeon must not forget that at least a portion of both the upper and lower ends of the intestinal canal can be relieved of pressure directly by means of intubation. A rectal tube passed well into the lower bowel will in a short time evacuate gas

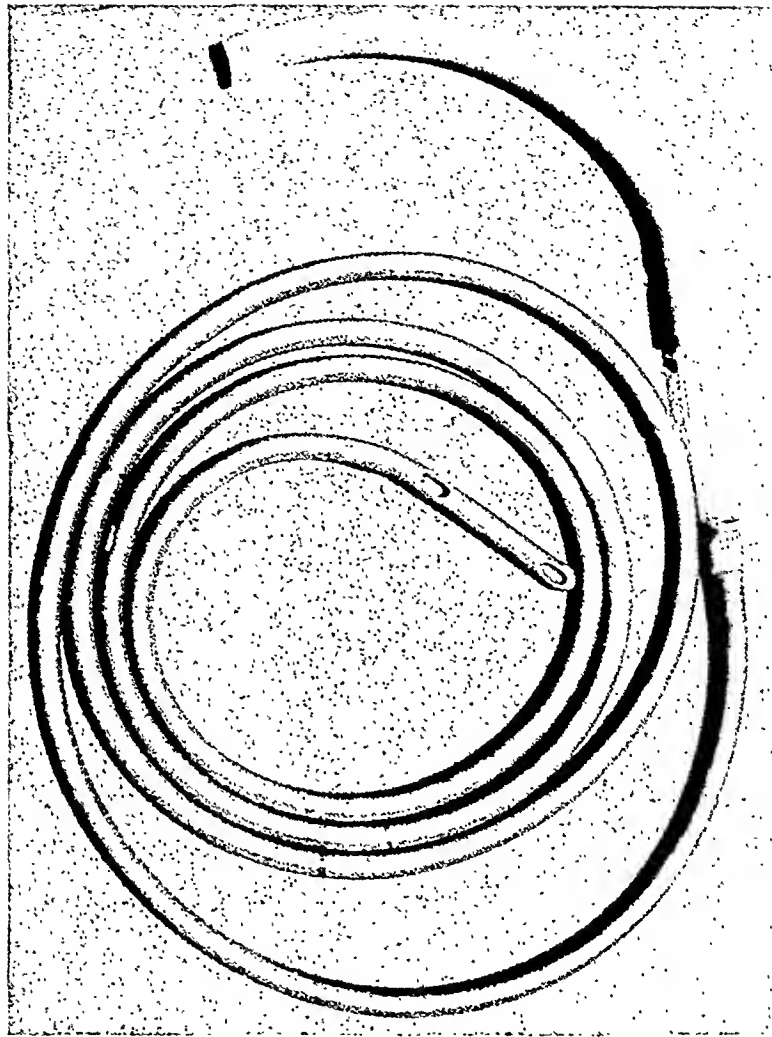


FIG. 45. Gastric or duodenal tube of the Levin type. Tube is essentially a long, slender, flexible catheter with four or more "velvet eyes" at the tip. Length of tube is from 45 to 60 inches, and it is made in various calibers, 16, 14, 10 F.; the first named is the best size for adults. Tube is marked with black circles 18, 22, and 26 inches from its tip. Levin catheter is designed to be introduced through patient's nose; it is soft and pliable, consequently easily introduced; being small in caliber it causes patient little inconvenience; it finds its way into the duodenum as readily as tubes with metal tips; because of its mechanical features it does not easily become clogged; probably such a tube is not so likely to produce trauma or pressure necrosis as a tube with a metal tip, especially when circumstances dictate prolonged continuous use.

from at least a considerable part of the colon, and a stomach tube passed, either through the mouth or, if need be, through the nose, will almost immediately empty the stomach and probably much or most of the duodenum (Figs. 43 and 44). Though it has been emphasized in the preceding pages that the intestine is impotent to empty itself of contained gas for some time postoperatively this is true only of portions somewhat removed from either end of the tract; even disorderly intestinal movements in portions of the gut near the stomach will be capable of regurgitating some gas into this viscus and, similarly, contractions of the terminal portion of the ileum, even though incoordinated, will pass some gas into the colon. The rectal tube and stomach tube afford fairly direct avenues of exit for such accumulations. The two simple expedients just mentioned add very much to a distended patient's comfort.

F. THE USE OF HEAT: Heat tends to relax muscular spasm, and this principle may be used to good advantage in cases in which gas pains are persistent in spite of the measures previously described. The time-honored turpentine stupe has relieved many a patient of distention and gas pains. Whether the turpentine used in the preparation of stupes has any particular value in itself is open to serious question; turpentine is a local irritant and rubefacient and shares the somewhat questionable advantages of other counterirritants. Undoubtedly the primary beneficent action of stupes is dependent upon their heat content. Probably in some cases, particularly in very thin persons, direct transmission of heat is possible through the skin and subcutaneous tissues to the musculature of the anterior abdominal wall; however, many patients present an intermediate pad of abdominal fat through which locally applied heat does not, in all probability, penetrate for any considerable distance. For this reason, probably most of the effect of the local application of heat is dependent upon reflex sedation. Both the abdominal musculature and the intestinal musculature respond clinically.

The hot stupe is not, however, really the most desirable form of heat application, provided that the therapeutic action of turpentine be not considered of particular importance. Considerable portions of the abdomen, as previously mentioned, are characteristically covered by dressings, and therefore the available surface to which stupes may be applied is ordinarily somewhat restricted. Furthermore, stupes not only impose an unwelcome burden of weight on the patient's distended abdomen, but they speedily lose heat and to be effective must therefore be frequently changed, a procedure which is burdensome both to patient and nurse.

The electric light tent or cradle is not subject to any of these disadvantages and presents certain additional desirable characteristics. It not only imposes no extra weight upon the patient's abdomen, but it relieves the burden of the bed clothes as well. Heat is applied not only to exposed portions of the abdomen but also to the part covered by dressings and the flanks. The supply of heat, furthermore, is constant and can be regulated at will. Clinically, the therapeutic value of the electric light cradle corresponds with its theoretical advantages.

Infra-red irradiation, diathermy, and possible other forms of physiotherapy may gain favor in the treatment of distention and gas pains as familiarity with these agents and facilities for their application become more common.

As previously mentioned, the administration of morphine may be found necessary in intractable cases, but a word of warning should be spoken in connection with the repeated administration of morphine in cases in which symptoms of distention and gas pains persist for a considerable period of time. One must not allow intestinal obstruction to develop unrecognized under the mask of narcosis. It must be emphasized again that postoperative distention and gas pains are self-limited conditions; complete absorption of gas is a matter of hours rather than days, and persistence of symptoms for more than from thirty-six to forty-eight hours should

stimulate a study of the case for some unrecognized intra-abdominal abnormality to account for a possible incipient ileus.

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CHAPTER IX  
DILATATION OF THE STOMACH

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## CHAPTER IX

### DILATATION OF THE STOMACH

#### I. DILATATION OF THE STOMACH

A. ETIOLOGY: Dilatation of the stomach may occur postoperatively in connection with any of the more radical operative procedures; it is rarely encountered as a complication of surgical manipulations which have not involved abdominal section, and it occurs most frequently in connection with gastric operations, biliary surgery, and operations on the female pelvis. The mechanism of the development of the condition is not well understood.

In connection with a possible etiological relationship between the Fowler or "semirecumbent" position and the development of gastric dilatation, Gibson and Wade<sup>1</sup> have compared two series of cases, one in which the ordinary flat position was used and the other in which the Fowler position was maintained. The range of operative procedures considered in the report was limited to surgical manipulations in the upper portion of the abdomen. The criterion used as to the existence of gastric dilatation was, however, the fact that gastric lavage had been performed. In the use of this doubtful criterion the incidence of gastric dilatation was significantly less in fully recumbent patients, and especially so in patients submitted to biliary surgery. The incidence of pulmonary complications was, however, slightly increased (2 per cent).

Two theories of gastric dilatation have been proposed; (a) one assumes that the dilatation of the stomach is secondary to mechanical obstruction high in the small intestine, (b) the other postulates a condition of paralytic ileus involving the stomach wall and possibly the upper part of the small intestine as well.

As possible causes of mechanical obstruction the rôle of (1) constrictions at or about gastroenterostomy openings and

(2) the production of duodenal ileus are most frequently considered. It is easy to understand how edema about the margins of an artificial stoma between the stomach and intestine might cause virtual obliteration of such an outlet to the gastric contents, or to picture a kinking of the intestine in the neighborhood of such an opening which might produce a similar obstruction. The occurrence of gastric dilatation is not, however, confined to cases in which gastroenterostomy has been performed and consequently such mechanisms cannot be considered as explaining all cases.

It has also been suggested that the etiology is sometimes similar to that found in certain cases of "duodenal ileus" in which there is a mechanical drag of the superior mesentery artery on the last portion of the duodenum, thus producing mechanical constriction of the lumen of the gut at that point. Whereas, however, this factor may be present in the later stages of gastric dilatation in which the weight of the gastric contents already present transmits traction on the mesenteric artery, the clinical picture of the two conditions is so different that the etiology cannot be fundamentally the same.

By a process of exclusion, therefore, and in the absence of other possibilities, one must assume that most cases of gastric dilatation represent essentially a paralysis of the muscular coats of the stomach, and this is the view most commonly held. The essential etiology of this paralysis is not known though, most probably, it consists essentially of some kind of intoxication.

To suggest, as some have done, that the dilatation is secondary to functional obstruction which is essentially reflex in character is to elucidate matters not at all.

**B. CLINICAL DIAGNOSIS:** Dilatation of the stomach usually occurs, or at least becomes clinically recognizable, within from twenty-four to forty-eight hours postoperatively.

The patient, who in the interim characteristically may have been observed to have vomited slightly more than patients ordinarily do as a result of taking an anesthetic, begins to

complain of a sense of epigastric fullness and distress and also to evacuate from the mouth quantities of thin brownish or greenish-black fluid. This fluid may be blood tinged in cases in which the intestine itself has been opened. The manner of the evacuation of this fluid is an important consideration in the recognition of the condition because the material in gastric dilatation is not vomited in any proper sense of the term but flows out of the mouth without much effort, a process which has been rather aptly described as "overflow vomiting." Furthermore, the evacuation of this material does not give the patient relief, and as time goes on the flow of stomach contents out of the corner of the mouth and over the cheek becomes virtually continuous.

Physical examination at this time shows on inspection considerable distention of the abdomen especially in the left upper quadrant and on percussion a large area of dullness corresponding to the outlines of the dilated viscus.

The passage of a stomach tube at this time reveals the presence of a large quantity of fluid in the stomach, often as much as two or three liters; the fluid obtained has, of course, the same physical characteristics as the material vomited. Careful measurement over a relatively long period of time of the amounts of material recovered by stomach tube and the amount of fluid intake which the patient is able to negotiate will show in a case of gastric dilatation that much more is regurgitated than is received, thus demonstrating that the stomach contents are actively secreted and do not represent material taken by mouth.

Due to excessive regurgitation dehydration rapidly ensues in cases of gastric dilatation not successfully treated, thirst becomes excessive, and the urine becomes scanty and highly colored. Collapse, characterized by the development of a rapid, thready pulse, a cold and moist skin, and shallow respirations, rapidly supervenes.

C. TREATMENT: Lavage is the treatment *par excellence* in these cases and should be instituted as soon as the diagnosis

is even suggested. Lavage may be repeated every six hours, or as frequently as necessary to keep the stomach quite empty, or, better still, a tube of the Jutte or Levin type may be introduced into the stomach and left permanently *in situ*. The free end of the tube in the latter case is allowed to drop over the edge of the bed to produce a siphonage action, and a syringe is attached and suction applied at frequent intervals to make sure that the apparatus has not become clogged.

It has been suggested that it is often possible also to place the patient in a modified knee-chest position with the hips elevated to a higher level than the head, thus favoring mechanical emptying of the stomach through the esophagus and mouth; but such a procedure is usually inconvenient, sometimes not feasible, and is rarely necessary.

Nothing should, of course, be given by mouth, but relatively large quantities of normal salt solution should be given hypodermically and intravenously. Morphine is indicated for the relief of abdominal distress.

D. PROGNOSIS: Untreated, many patients die of gastric dilatation. When the condition is recognized early, however, and is properly and energetically treated all patients recover.

## II. THE USE OF THE STOMACH AND DUODENAL TUBES

The use of both stomach and duodenal tubes, especially the stomach tube, constitutes a very important adjunct to the treatment of a rather considerable number of postoperative surgical cases. The use of gastric lavage as a routine measure in all cases receiving general inhalation anesthesia has already been discussed, and although it is not perhaps usually considered necessary or even advisable to construe the proper use of gastric lavage too broadly, patients as a rule undoubtedly do better when the stomach is kept clean by artificial means. Gastric lavage is usually indicated one or more times in all cases of upper abdominal surgery; so true is this that in cases of biliary and gastric surgery, at least, the medical attendant should become accustomed to reaching for the stomach tube

almost by instinct whenever the condition of the patient shows a tendency to become unsatisfactory.

A. INDICATIONS FOR GASTRIC LAVAGE: The indications for gastric lavage consist (1) in the presence within the stomach of gas, blood, undigested food, bile and intestinal contents regurgitated from the small intestine by a process of reverse peristalsis, and (2) in the presence within the stomach of abnormal secretions derived from the stomach wall itself. The recognition of the presence of such substances within the lumen of the stomach is not always easy clinically. Distention in the region of the costal angle is always presumptive evidence of dilatation of the stomach, and persistent vomiting or vomiting presenting the characteristics described as "regurgitant," i.e., the type in which bile stained dark colored material flows out of the mouth and over the cheek without apparent effort, presents additional evidence of the development of dilatation. Not infrequently, however, the condition of the patient raises no suspicion of gastric dilatation, the only indication of the presence of foreign material within the lumen of the stomach being such vague symptoms and signs as restlessness, a drawn countenance, epigastric discomfort, rapid pulse, or merely an indefinite feeling that matters are not going as well as they should.

Patients after recovery from a general inhalation anesthesia are expected to vomit once or twice, and mild nausea is expected to persist for three or four hours. Repeated vomiting and unduly severe or prolonged nausea in the absence of actual vomiting constitute presumptive evidence of gastric irritation secondary to the presence of toxic secretions, and gastric lavage should be invariably performed in such cases.

B. TECHNIQUE OF GASTRIC LAVAGE: Gastric lavage can be a relatively simple and clean procedure or an obnoxious, soiling, and unpleasant one depending partly upon the cooperation which the patient is able or willing to give and partly upon the technical skill of the attending surgeon. The passage of a tube through the esophagus into the stomach is, even at best, not a

particularly pleasant proceeding for the conscious patient. The most difficult part of the entire performance is the passage of the end of the tube through the fauces and into the first part of the esophagus. The tolerance of the palate, nasopharynx, and pharynx of patients to mechanical stimulation varies considerably, and an amount of stimulation which may cause no unappreciable degree of discomfort to one person may be absolutely intolerable to another.

Other things being equal, the amount of such stimulation will depend to a considerable extent upon the size and pliability of the tube selected for use. A large stiff rubber tube unskillfully forced through the fauces will often throw the pharyngeal muscles of even a tolerant person's throat into so violent a spasm that the respiratory passage becomes occluded, violent choking and gagging ensue, the face becomes cyanotic, and the patient either tears the tube in terror from the attendant's hands, or if restrained so that this is impossible, promptly projects the contents of his stomach through the tube with such violence as to soil himself, the bed, and very likely the attendants as well. Smaller and more pliable tubes are less likely to cause inconvenience, but really small tubes cannot always be used because not infrequently the stomach contains particles of food or blood clot, or conglomerations of mucus which require removal and which cannot be evacuated through such a tube because of the small size of its lumen. One of the advantages of routine gastric lavage on the operating table and before the patient has recovered from the effects of the anesthetic is that lavage with a relatively large tube is customarily required but once, and if this be performed while the patient is unconscious particulate stomach contents are removed thereby and a relatively small tube may be used subsequently in the event that lavage becomes desirable after consciousness has been regained. The size of stomach tube to be used in any given case depends, thus, on the character of stomach contents requiring removal, and when possible very



small flexible tubes especially tubes of the Jutte or Levin type are preferred.

Stomach tubes must, of course, be sterilized prior to use, and if possible should be free from stains and unsightly marks because of the unfavorable psychic effect which such factors may have on the conscious patient. Tubes are tolerated best when thoroughly chilled, and they are therefore placed on ice after being sterilized, and, as before, in selecting the basin and preparing the ice a favorable psychic effect is to be sought whenever possible.

Patients swallow best when in the upright or partially upright position, and whenever feasible should be allowed to sit up in bed properly supported, of course; or if this is impossible the head should be at least slightly raised from the pillow. In connection with this procedure a rubber bib, rubber sheet, or similar protective device is arranged about the patient's neck and down over the chest and bed clothing to prevent possible soiling of the patient and his linen.

Patients usually submit to gastric lavage best if they are previously appraised of just what is to be done and exactly what is to be expected of them. They are told that they are to be caused no pain, but that the procedure about to be performed may cause them to gag and that this tendency may be overcome by assisting all they can in swallowing the tube and in resisting any inclination to expel it by focussing the attention on breathing through the mouth.

When passing the tube the operator stands either directly behind or at the side of and slightly behind the patient, steadies the head of the patient with one hand and introduces the end of the tube, previously well lubricated with some suitable lubricant, through the fauces and directly into the pharynx without touching the soft palate, the pillars of the fauces, or the uvula. The introduction of the tube should be continued into the esophagus neither too rapidly nor with too much deliberation, the movement being executed steadily and no attempt being made to force the procedure. During this pro-

cedure the patient should be reassured and encouraged to swallow, but if gagging ensues the tube is temporarily arrested in its course and the patient is admonished to breathe through the mouth in short quick gasps, after the manner of the panting of a dog.

Once an attempt has been made to pass the tube every effort should be made to avoid withdrawing it because if initially unsuccessful in completing the procedure subsequent attempts may be increasingly difficult.

Patients have difficulty in swallowing a tube coated with vaseline or other frankly oily materials, and especially materials having distinctive odors or tastes. Unflavored water-soluble lubricating jellies or glycerine make the most suitable substances for lubricating purposes.

Once the tube has passed into that part of the esophagus possessed of involuntary peristaltic activity no further difficulty should be encountered.

In cases in which the passage of the tube is well tolerated spontaneous vomiting does not occur through the tube, and suction must be applied to the free end of the tube to start evacuation of the stomach. Suction may be applied by means of a syringe or siphonage suction may be employed in suitable cases by first completely filling the tube from its free end with water and then quickly lowering this end of the tube below the level of the stomach.

The stomach after the primary evacuation has been completed should be alternately filled with cleansing solution and reemptied until the material obtained shows no further evidence of contamination. Plain water at a temperature of from 110 to 120° F. may be used for this purpose, though a 1 or 2 per cent sodium bicarbonate solution usually serves somewhat better because it favors the liquefaction and dislodgment of any mucus that may be present.

C. CONTINUOUS GASTRIC DRAINAGE (JUTTE TUBE): Under certain circumstances there occurs in the stomach postoperatively an accumulation of gas, intestinal contents, or a com-

bination of both which tend to become continually augmented and therefore presents indications for continuous removal. Such an accumulation occurs characteristically (a) in gastric

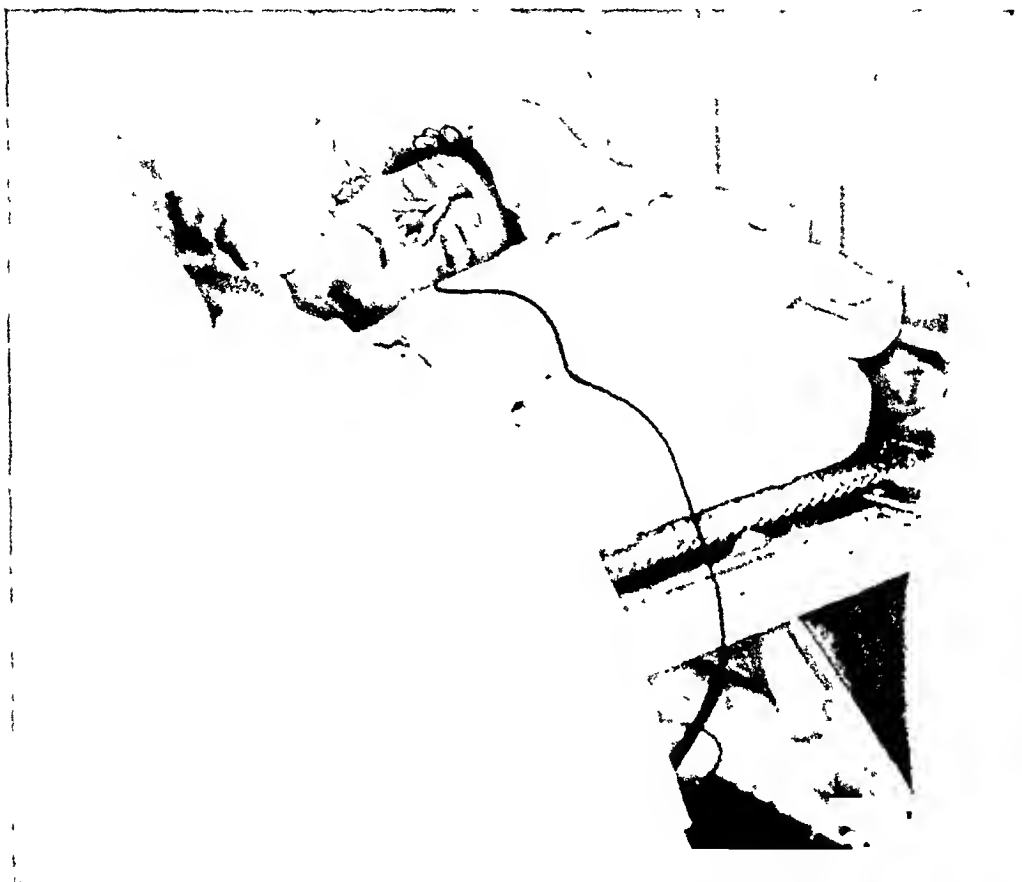


FIG. 46. Use of continuous gastric lavage. A small stomach tube has been passed through the nose. Tube has been fastened in place to bridge of nose and forehead by strips of adhesive plaster. Free end of tube drips into receptacle on floor.

dilatation in which the accumulation represents mainly an abnormal secretion from the walls of the stomach, (b) in intestinal obstruction, whether paralytic or dynamic, in which case reverse peristalsis carries material antiperistaltically from the intestine to the stomach, (c) in various reflex irritative conditions especially such as are connected with gall-bladder disease, and (d) in certain aggravated cases of abdominal distention, the accumulation in this class of cases consisting mainly of gas.

The repeated passage of a stomach tube for purposes of withdrawing such accumulations is irksome to the medical attendant, unpleasant for the patient and relatively inefficient as a method, since during a considerable period of time between successive passages of the tube variable amounts of material are left within the stomach cavity. In all of these types of cases continuous drainage is much more rational and is easily provided by means of the introduction of a stomach tube of small caliber through the nose (Jutte tube), which tube can be left in situ for as long a period as may be indicated by the mode of progress of the case, occasionally for days (Fig. 46).

The distance from the incisor teeth to the stomach in the adult is about 15 in. and this distance is usually marked on tubes designed for purposes of gastric lavage; an inch or two in excess of this length is allowed when tubes are introduced through the nose.

The tube used may be provided with a perforated tip or "sinker" of metal or the Levin catheter type of tube may be used and perforations are also provided in the wall of the tube for a distance of 2 in. or so proximal to the metal or rubber tip in order to allow additional drainage. After being introduced the tube is anchored to the cheek of the patient with suitable strips of adhesive plaster. Its free end is made of sufficient length to hang over the edge of the bed and is arranged to empty into a suitable bottle or other receptacle, the latter being either placed on a low stand beside the bed or hung therefrom.

The Jutte, or Levin, tube because of its small caliber allows only the passage of gas and fluids and is not suitable for use in cases in which blood clot and relatively large pieces of undigested food and other debris require removal. It does not interfere with the passage through the esophagus into the stomach of liquids taken by mouth; consequently water and other liquids either hot, cold, or tepid as may be desired may

be given the patient to drink and may be just as readily withdrawn or expelled through the tube if so desired.

If a siphonage action be started by suction applied to the free end of the tube, fluid will continue to flow from the end of the tube as long as it is provided by mouth and in this way a continuous gastric lavage may be instituted. By this method there is provided a very ready means of applying heat to the body or withdrawing it therefrom, since such a process (as suggested by Matas<sup>2</sup>) virtually converts the stomach into a hot water bottle or an ice bag as the case may be. The stomach lying as it does just below the heart, and being in intimate relation also with the liver, vena porta, vena cava and aorta is ideally located for the purpose, and the degree of regulation of body temperature which can be gained by this procedure is remarkable.

D. THE POSTOPERATIVE USE OF THE DUODENAL TUBE: That toxins absorbed by the upper portion of the intestine are responsible for acute dilatation of the stomach and occasionally hiccough is held by many, and that absorption of any other toxic product which may be present in the gastrointestinal tract is more rapid from the small intestine than from the stomach has been recently asserted.

Soresi<sup>3</sup> believes that a certain number of patients succumb postoperatively as the result of absorption of stagnated duodenal contents. He has found experimentally that dogs which have undergone gastrectomies develop a more or less distended parietic condition of the duodenum, which latter is found filled with a chocolate colored fluid even in the absence of any obstacle or obstruction to the passages of this fluid in either direction. He believes that the clinical condition noted in the case of certain patients who fare well for three or four days following operation and in whom the pulse thereafter becomes irregular, more frequent and small, the temperature subnormal, and the skin clammy and covered with cold perspiration is due to absorption of this material. Usually, he believes, the absorption of this material is not accompanied by noticeable ill

effects, but holds that patients who have undergone severe operations on the organs contained in the upper right quadrant of the abdomen, being characteristically in a poor general condition, not infrequently succumb as the result of toxemia so induced.<sup>3</sup> Fortunately the duodenum as well as the stomach can be drained with facility.

The method of transduodenal lavage was originally described by Jutte, in 1912,<sup>4</sup> as a method of value in the treatment of certain chronic medical diseases. Surgeons were not slow, however, to adapt the principle to their own purposes in the post-operative care of surgical patients, and this method has come to be quite generally recognized as of value in the treatment of certain surgical exigencies.

Jutte<sup>5</sup> has very aptly compared the cleansing effect of transduodenal lavage of the small intestine to the use of the enema in evacuating the colon. The advantages of transduodenal lavage over gastric lavage consist mainly in the avoidance of irritation of the gastric mucosa which is prone to eventuate in vomiting and in the fact that by the technique under discussion a part of the intestine presumably concerned directly with (a) the absorption of toxic substances on the one hand, and (b) with the absorption of fluids on the other is rendered immediately accessible.

The useful purposes subserved by the proper use of the duodenal tube as listed by Oden<sup>6</sup> include the following:

1. Relief of distention.
2. Prevention of nausea.
3. Removal of toxins.
4. Supplying of fluid.
5. Instillation of therapeutic agents.

The armamentarium required for transduodenal lavage by the Jutte technique is relatively simple, consisting of a  $\frac{1}{16}$  in. thin-walled duodenal tube with a metal olive attached at the end, the tube being itself perforated in the region of the olive, and a suction apparatus which may consist simply of an

ordinary syringe, and some means of irrigating through the tube, either a funnel or possibly a syringe.

The patient swallows the duodenal tube, turns on his right side on the table or bed, and drinks a glass of water. The water distends the stomach slightly and favors the gravitation of the metal olive to the region of the pylorus; within about twelve hours peristalsis carries the olive through the pylorus into the duodenum. By aspirating from time to time and noting the appearance of the aspirated material, one may judge the position of the olive and perforated part of the duodenal tube. Jutte<sup>5</sup> says that except in cases of gastric catarrh the aspiration of material which is stringy or tenacious indicates that the area being drained is intestinal and not gastric, and he thinks this test is more valuable than tests for acidity with litmus paper, since on the one hand the contents of the duodenum may show a temporary acidity due to massive evacuation of stomach contents just previously, or on the other hand the gastric acidity may have been almost or completely neutralized by regurgitation of duodenal contents through the pylorus.

The duodenal tube serves one useful function not available in connection with the ordinary stomach tube. The stomach, as mentioned elsewhere, absorbs fluids to only a very slight degree if at all; the duodenum, however, absorbs them readily; consequently the introduction of fluids for purposes of absorption is much more likely to succeed in connection with duodenal intubation. The administration of fluids by "duodenal drip" is frequently very successful. Such a tube may be left *in situ* for as long as seven days if desired, but because of the possibility of the formation of pressure ulcerations along the course of the tube and more especially about the terminal metal olive the tube should not be allowed to remain longer than necessary.

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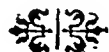
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